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# EDITORIAL

## A Dynamic Approach

A "Teaching Seminar" might sound like the height of pedagogic isolation from the mundane practical problems of life.

But where the teachers concerned are agricultural engineers; when there is a world crisis in food production; when there is a postwar shortage of all types of engineers, including agricultural engineers; when war-decimated college departments of agricultural engineering are in the midst of reconversion to accommodate a postwar backlog of young men seriously intent on preparing themselves for lives of service in agriculture and its related industries, it becomes a highly practical approach to the very foundations of progress.

One of the healthiest signs that can be seen in any group, anywhere, any time, is open recognition of room for improvement in its accomplishments and results. Dominating spirit of the Agricultural Engineering Teaching Seminar at Purdue University, August 30 to September 4, was recognition of opportunity for improvement, and concentration on ways and means of accomplishing it.

With 150 teachers of all ranks, from all primary agricultural regions of the United States and Canada, brought together in concentration on this problem, there was more than a casual exchange of academic views and information. There was pressure, individually and collectively, to consider all of the angles and to assimilate the best information applicable to specific problems which will confront the various departments and individual teachers in the new school year; to be prepared to meet those problems with renewed vigor.

Agricultural engineering teachers have a responsibility to themselves, to agricultural engineering, to the teaching profession, and to agriculture — to build and maintain a reputation for a dynamic subject matter, dynamically taught. The Seminar was a dynamic approach to their immediate problems in living up to that responsibility.

## Ag Engineers in Watershed Control

SOIL and water conservation practices are obvious influences on farm power and machinery, structures, and electrification. Tillage and dirt-moving equipment, cropping systems, livestock programs with their related buildings and electric uses, and farm purchasing power, are particularly sensitive to progress, and to the remaining sins of omission and commission in the farm handling of soil and water.

Agricultural engineers in other branches of the field who want to keep reasonably well informed on soil and water conservation progress, and its possible implications to them, will be particularly interested in the paper, entitled "Agricultural-Engineering Problems in Watershed Planning," by A. W. Zingg, found elsewhere in these pages.

Precipitation in Montana, Minnesota, and Pennsylvania, which is of economic interest in Louisiana, Mississippi, and wayside points, is bound to be the subject of endless controversy. Conflicts of interest arise, not only between agriculture and other uses, but between agricultural areas and between neighboring farmers. Controls at any one point may be positively destructive to farming interests at or near that point, while having little or no measurable effect upstream, and problematical value downstream.

Zingg lists seven needs of agricultural watersheds which can be economically met in some measure in specific cases by application of six general types of controls, individually or in appropriate combination.

It is particularly significant that "on small upland areas, a land program, including ponds and small storage devices for beneficial local uses, will often provide the only management of runoff that is feasible. . . . Such controls and uses of water are beneficial to all downstream points and have no conflict with any other conceivable control or use."

Of the six general types of controls, four are applicable to this upstream engineering, and on the scale of operations involved, are largely matters of agricultural engineering. They are conservation farming methods, dams, diversions, and drainage ditches. The other two controls, stream rectifications and levees, are of limited application in upstream engineering.

From this viewpoint it appears that agricultural engineers in soil and water conservation have the opportunity to make a major contribution to watershed control, without becoming involved in the slugging matches between conflicting interests. Agricultural engineers in other fields will find new opportunities to implement this work, and the improved farming which will follow.

## Family Farm Opportunity

BURIED in a report to the governor and people of the State of New York is a point so timely it might well be headlined, broadcast and set to music to be carrilloned from "far above Cayuga's Waters" to a world wandering in a wilderness of post-war economic confusion.

The report: The 58th Annual Report (1945) of the New York State College of Agriculture and the Cornell University Agricultural Experiment Station.

The part: Summary of a farm-labor simplification project.

The point: " . . . in general, over a period of time, labor, whether in agriculture or industry, is paid for what it produces, and according to what it produces."

For the sake of argument, we might add that management and capital are similarly paid for their respective contributions to economic production.

It is particularly significant in these times that in farming, labor, management, and capital are so closely related. Often the return for each service or factor in production ends in the bank account of the same family.

From a cost-accounting standpoint the contribution of each may be computed, as a guide to balance and effective use in production, but from a standpoint of social or economic justice, or net income, the farm family which is a fairly complete producing unit has no quarrel within itself as to which pocket receives the most money. It is free to operate without the factional friction which is delaying production in some of the large corporations.

Substantial progress has been made, and is continuing, in farm understanding of basic factors in production and income.

A sound lesson has been learned in the fact that the economic production of a farm is measured not only in bushels and tons, but by demand as well.

It has been made clear that demand, even for food products, is extremely sensitive, not only to world politics and production, but to domestic production costs and buying power. Production costs are subject to some measure of control by the farmer. *(Continued on page 422)*

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# A Coordinated Design of Farmstead Structures for Improved Efficiency

By W. R. Peterson
MEMBER A.S.A.E.

WE usually consider ourselves a forward and progressive people, yet our thinking is still largely influenced by tradition and past practices. This is particularly true in the older agricultural arts, such as farm building design.

Even in the newer arts, such as farm tractor design, we were several years in realizing that engine power could be more efficiently applied if taken directly to a machine through a power take-off shaft, rather than first converting this power to tractive effort and then subsequently picking it up through ground drives and gear trains. If the horse had been equipped with a power take-off, we would not have fallen into this error. In many other cases the physical make-up of both man and beast have been the determining factor in machine and building design as well as in field practices, and dimensions resulting from such physical make-up have persisted after the reasons for their continuance have disappeared. One of our friends in another profession remarked a few years ago, with a great deal of truth, that the horse's rump has had more to do with the spacing of corn rows than all the engineers and agronomists put together.

By the same token many building dimensions have been developed to accommodate the workman, the manure spreader, or other implements, and the space required to store loose hay. The following examples are cited:

1 To clean mangers and perform feeding operations efficiently by manual methods, it has been found desirable to have feed alleys about 4 ft wide.

2 To promote quick removal of manure, it has been desirable to provide enough room to drive through the barn with a team of horses and a manure spreader. This requires about 8 ft of width if the workman is to have room enough to work.

3 With the tendency toward lower roof lines, the storage of loose hay overhead has created a need for barns of considerable width.

These design factors have resulted in barn widths of about 36 ft, or about 65 sq ft of floor area per cow. This, with ordinary types of construction, is not excessive in cost, but the cost is likely to be high enough that the farmer cannot tolerate too many frills, such as fire-resistant construction and built-in machinery. We are referring now to the average good dairyman who may be located anywhere and who may be selling cream to creameries, or milk to cheese factories of condenseries. We are not referring particularly to the dairyman in the fancy price areas, to whom building costs are obviously of less importance than to the producer of lower priced milk, although the dairyman in the fancy price area is not excluded from consideration, for he too is interested in low building cost and high efficiency.

To us it seemed that mechanisms for handling feed and wastes superimposed on building costs which are already quite high was not likely to be a good answer, and yet there is clearly a demand and a need for mechanisms of this nature. With this idea in mind, we began casting about for ways to mechanize the farmstead without adding too much to building costs.

Our primary interest is in a small dairy farm, which we are developing in conjunction with our other research activities. In setting up a system for this farm we first accepted the following as logical limitations:

1 No tractor exceeding 20-22 bhp is likely to be available to the farmer, or to his neighbors, who are also small operators.

2 The number of machines necessary for farm operation shall be kept to a minimum.

The following advantages are presumed to exist:

1 The farm shall be completely equipped so as to leave the farmer in full command of his own operations without the need of depending on custom operators, except that in some cases, such as the field baler, field ensilage cutter, corn picker, and corn sheller, the operator will cooperate with one or two, or more, of his neighbors for the purpose of reducing machine investment and forming an efficient crew.

2 A reliable source of electricity is available.

3 The operator shall be of average intelligence and shall have a congenial attitude toward machines and be sympathetic toward good farm practices.

Air view of farm buildings arrangement at the International Harvester Experimental Farm near Hinsdale, Illinois

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946.

W. R. PETERSON is resident engineer, experimental farm, International Harvester Company.

4 It is further presumed that at least part of the time saved by mechanization shall be utilized in productive enterprise and not squandered in unproductive activity. That is, time saved in the barn would be utilized to care for an increased livestock population.

We first decided that the mechanical handling of farm crops from the field to storage should be done with an efficient all-purpose wagon capable of delivering any field crop, by means of a self-contained elevator, to a reasonable height, that is, 10 ft or less. We envisage this all-purpose wagon as a two-wheel, rubber-tired wagon with a hitch designed to take the labor, strain, and danger out of the coupling and uncoupling process. The elevator may be powered either through the power take-off, or by a supplementary motor unit.

In our design of farm buildings we have presumed that this wagon will be available. We have hereby eliminated two costly devices for elevating field products into storage, namely, the elevator and the silage blower, and have made unnecessary the heavy tractor which is generally considered to be needed for operating the silage blower.

### SPECIAL EQUIPMENT TO BE USED TO ELIMINATE LABOR OF HANDLING BALED HAY AND STRAW

To eliminate the labor which results from repeated handling of baled hay and straw, we propose to borrow a page from industry and collect these bales in small lots of about 1½ to 2 tons each on light, low-cost pallets, or bale sleds, on which these bales will remain until they are ultimately fed or used for bedding. For easy, rapid transport the pallets will be moved on a very simple, low-down, two-wheel truck, like a buck rake in reverse. These pallets will be loaded directly from the pickup baler and immediately covered with canvas or waterproof paper.

If the pallet of hay is to be stored temporarily outdoors, it will be covered by canvas until such a time as it is convenient or expedient to move it indoors. If the pallet is to be stored permanently outdoors, it will be covered with a low-cost asphalt paper, such as Sisalkraft, which will remain in place until the hay or straw is to be used. Preliminary research indicates that this outdoor storage may be accomplished at a very reasonable cost.

The pallet system with either temporary or permanent outdoor storage has one advantage with respect to hay quality. If this system is fully exploited, it should be possible to bale hay with a moisture content sufficiently high to prevent undue loss of leaves and carotene. If loosely tied, covered, and stored outdoors for a time, we are confident that the farmer can thereby realize a satisfactory forage product at a very reasonable cost. The covers for these stacks of bales would be such as to divert rainfall from entering the stack, and yet permit relatively free circulation of air. The danger of barn fires through spontaneous combustion is also eliminated by this approach.

If indoor storage space is not to be provided, the pallets with their loads of hay will be stored in the yard in some out-of-the-way spot. When needed for feeding the pallets will be picked up and moved to a location near the barn, most likely under an extension of the barn. When the hay or straw on the pallet has been used, the pallet will be folded and stored until the next season.

Another advantage of this system of handling hay is that, in the event of threatening weather, the hay can be covered quickly and left standing in the field while the baling operations continue without the long interruptions which invariably result from hauling to the barn and unloading the bales into conventional storage space.

* * *

The upright round silo has been widely accepted by dairy farmers throughout the country, and there is no indication that it will be discarded. For the small operator, however, it has a number of disadvantages:

1 Since the upright silo must always be at least 35 to 40 ft high to insure good quality feed, the small operator enjoys practically no relief from the demand for a large tractor to operate the blower.

2 In severe winter weather an excessively high percentage of the silage will freeze, making removal difficult and feeding results unsatisfactory.

3 Silo cost per unit capacity is quite high in the smaller diameters of silos.

4 The time required to climb into the silo and return from it when removing silage is excessive as compared with the actual time required to remove the silage from the silo.

5 It is not feasible for the small operator to have both corn and grass silage even though other conditions indicate he should have both, since the diameter of each silo would be so small and the unit capacity cost so high that the average operator could not tolerate the overhead cost resulting from the duplicate structures.

Because of the handicaps of the upright silo, we have decided in favor of a trench silo, to be built parallel to the row of cows. This trench silo is to be built 15 ft deep, 6 ft above grade, and 9 ft below grade. The above-grade portion is confined to a 6-ft height to permit lighting the stable through a 2-ft height of glass above the silo wall. This wall, the inside wall of the silo, is also the outside wall of the stable. Having this wall common to both structures will reduce construction cost and also reduce heat losses from both stable and silo. Another reason for confining the silo height above grade to 6 ft is that this permits filling rapidly by means of the self-unloading wagon, which has already been mentioned.

A width of 6 ft has been chosen to prevent excessive top spoilage and to keep machinery costs down to a minimum.

### TRENCH SILO WILL CONTAIN SUFFICIENT FEED FOR COW THROUGH A NORMAL FEEDING SEASON

The cross sectional area of this silo is such that a length of silo equal to the width of a cow stall will contain sufficient succulent feed to care for that cow through a normal feeding season. This feature of design has been chosen to make it easy to keep the size of the herd and size of the silo in balance. Obviously, each added stall will require added length for the barn and silo, thus with one standardized machine for removal of silage almost any size of herd can be accommodated.

The machine to remove silage will advance horizontally through the length of the silo, removing silage from a vertical face by means of buckets traveling in an upward direction. This silage will be deposited in a hopper suspended on scale beams. When the necessary amount for one feeding has been accumulated in the hopper, the elevating mechanism will be stopped and the filled hopper returned to the end of the silo, where it will be emptied into a device for portioning the silage to the cows.

I will enumerate an advantage of this system of silage removal. It is likely that, for various reasons, a farmer may wish to make both grass silage and corn silage. In choosing dimensions we have anticipated this possible desire. As stated before he will not wish to have two small silos. Neither will he care to put two kinds of silage into an upright silo, since this would mean a midseason change in feed — an undesirable practice.

With a trench silo, emptied from the end and filled from the top, the farmer will be permitted, if he wishes, to

have two kinds of silage stored in the same silo and will be able to feed these two kinds simultaneously in the same ratio as they exist in the silo. If grass is to be ensiled in June and corn in September, there will probably be some spoilage during the time between. We believe, however, that with careful attention to the top surface after filling plus the use of some sort of preservative, such as salt, the loss through spoilage can be kept very low. We hope that it can be kept so low that removal of the top surface previous to the fall filling will be unnecessary. Similar treatment following the fall filling with corn should result in very low losses at this time.

Considerable salt can be tolerated as a preservative since it will become thoroughly mixed with the silage in the handling process and will never appear in an excessive amount in the daily ration.

It is a well-known fact among farmers that frequent attention to the top surface for about two weeks following silo filling will reduce losses from top spoilage to a figure that becomes negligible. By avoiding the long difficult climb to the top of a tall silo for this daily chore, proper attention to the top surface will be promoted with resulting lowered losses.

Another distinct advantage of the trench silo is that it may be refilled repeatedly without the labor and hazards of erecting a blower several times.

In our earliest consideration of barn mechanization we were trying to conceive a system of mechanized feeding that would convey the various feeds along near the manger and empty these feeds into the manger in amounts appropriate to the needs of the individual cow. It soon became evident that the problem of doing this and keeping everything clean was almost impossible to solve and must always result in high capital costs.

We finally concluded that the answer lay not in conveying the feeds to a manger, which must later be cleaned by hand and much machinery with it, but in letting the manger itself come to a focal point for filling and then traveling to the cow for feeding. On the return trip the manger would be cleaned, and it may be sterilized by heat or ultraviolet light, or by a chemical wash. An endless metal, cotton, or glass fabric belt appears to offer the greatest promise in barns of ordinary lengths. Either rubber or some plastic impregnation such as vinyl resin would be necessary on the cotton or glass fabric belt.

Through this simple device several things have been accomplished, as follows:

1 The feed alley has disappeared so the cow has no inaccessible place in which to toss her hay and silage.

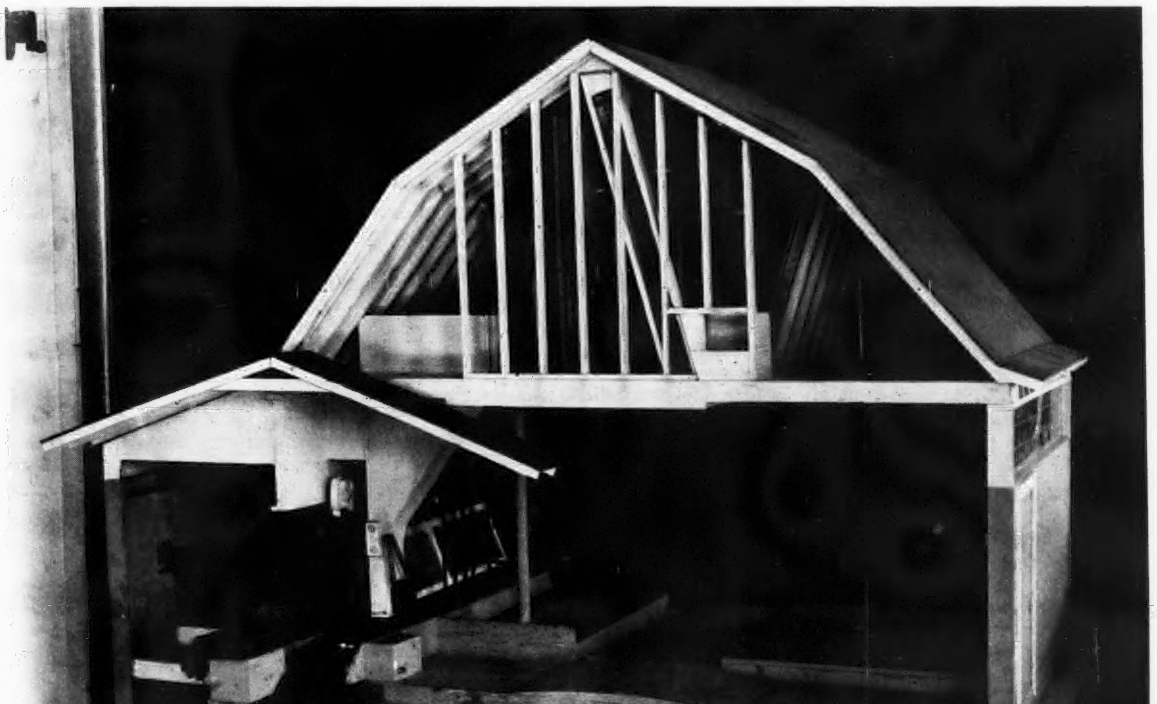
2 Four feet of building cost and heat loss has been eliminated.

3 The herdsman's feet and broom have gone from the manger with their attendant risks of infection and disease.

4 The time and labor required to feed and clean have been saved, allowing the operator to take care of other details of his work.

Time will not permit thorough discussion of the mechanical details of the feeding mechanisms, but these details have been developed to a point where we are confident that the most exacting dairyman will be well satisfied with the precise manner in which the various feeds can be portioned out to the individual animal according to her particular needs.

As mentioned before the total weight of silage necessary



View of cutaway model showing some details of the dairy farm feeding mechanisms discussed in Mr. Peterson's paper

for one feeding for the entire herd will be collected and weighed in the silo and returned to the end of the silo which adjoins the silo room, or more properly, the feeding room. This silage may be divided among any number of cows in any proportions desired, even to the point where an empty stall will be by-passed in the feeding process. This particular problem was a difficult one, and for a time it appeared that there was no simple practical answer. Finally, however, a relatively simple solution was reached which involves only the simplest machine elements.

Next we come to the hay feeding part of the mechanism. It is our plan to feed baled hay. As regards the mechanisms for feeding hay and grain, we did not have the problem of completely emptying a supply hopper as we did with silage, since hay and grain which are not fed immediately will not deteriorate as silage will. The hay bales are placed in a rectangular trough at the end of which is a sort of beater or shredder which removes hay from the end of the bale and deposits it in the manger as the bale is forced forward by a pair of chains and a cross bar. The movement of these chains and cross bar is intermittent, and the duration of each forward move determines how much hay that particular cow is to get. By simply lifting a small pin and placing it in the proper hole the amount of hay for the individual cow is determined and she will continue to receive just that amount at each feeding until another change is made in the position of the pin for that individual cow. If cow is absent from her stall for any reason, the pin is simply removed and no hay will be placed in front of her stall.

### GRAIN FEEDING WILL BE ACCOMPLISHED BY GRAVITY FLOW FROM BIN ON UPPER FLOOR

Grain feeding will be accomplished in the same manner, with the grain flowing by gravity from a bin on the upper floor onto a fluted wheel. As the wheel rotates it will remove grain from the bin and place it in the manger. Control will be identical to that used for the hay and adjustment of the amount of grain fed will be accomplished in the same manner.

These two feeding operations, hay and grain feeding, will thus require that there be provided two control bars for each stall, with one adjusting pin for each bar. These bars will be actuated by means of lugs on the manger belt, or, more likely, by lugs on a separate chain synchronized with the manger belt.

The entire bank of control bars for hay feeding will operate a common switch through a simple mechanical linkage. The entire bank of control bars for grain feeding will operate a second switch through similar linkage. For control of silage feeding two switches will be required.

In addition to these controls just mentioned, there will be three manually controlled switches for selection of the proper feeding cycle, that is, to feed silage and grain, or to feed hay; or any one may be fed alone or all three together. If the herdsman wishes to feed a proportionally reduced amount, such as a light midday feeding of hay, this too can be easily accomplished with one very simple adjustment which will not upset any of the adjustments for the individual cows.

Manure removal and barn cleaning have been carefully considered, and although no final choice has been made in this respect, some mechanical assistance will unquestionably be employed. It does not appear likely that an endless traveling chain with flights crosswise of the gutter can be justified since the cost of this system appears to be out of proportion to the time that can be saved.

Mention has been made of a litter alley about 4 feet wide. This width would be quite satisfactory for barns of 10 to 15 cows capacity, but would likely need to be increased slightly for larger herds to prevent undue crowding and confusion while the cows enter and leave the barn.

In the small barn the side opposite that used for the cows will be taken up by the bull pen, maternity pen, calf pens, dairy room, and vestibule.

Feed storage, except ear corn, would be provided above the stable, with facilities for weighing, grinding, mixing, and placing in convenient bins or hoppers for the dairy stable, hogs, chickens or other needs.

To say that this design is compact is probably an understatement. We have intentionally kept all dimensions to a minimum for reasons which have already been stated. We incline to the belief that full mechanization of farm chores is just as natural an objective as any other mechanization problem and that the time to be saved during a full year probably exceeds that which can be saved through any other single move toward mechanization.

The small farm with diversified activities is probably more in need of a mechanization program than is the large one because the proportion of time spent between jobs to the time spent on the job is greater where the jobs are small than where the separate jobs are large as in the case of the large farm.

### A SYSTEM OF MECHANIZATION SUPERIMPOSED ON HIGH BUILDING COSTS BELIEVED JUSTIFIED

As stated before, however, we have felt that we could not justify a system of mechanization superimposed on building costs already quite high, which accounts for our effort to achieve compact and efficient design.

We have collected some data in the barn which is now in use at our farm, with respect to the time required to do the chores which we have assumed can be mechanized. Our barn is probably about average as it affects labor efficiency and the men who do the chores are average workers.

We find that our chore time per cow is 5.7 min in a herd of 35 cows. This time requirement per cow for a herd of 15 cows would result in a total time demand of 85.5 min per day. If we now further assume that 75 per cent of this time can be saved, we would have a saving of 64 min, or 1.07 hrs per day. For a feeding season of 180 days, the total time saving would be 192 hrs. If 40c per hr is taken to be the labor cost for farm help, we would achieve a saving of $77 per year. Again making an assumption that the life of the barn and machinery would be about 12½ years, a figure that has been used elsewhere in similar analyses, we will arrive at a value of $962 for those mechanization features which have been discussed here.

Calculations of building costs indicate that the reduction in cost of construction, not considering the silo, would equal or exceed this labor-saving value.

In view of these qualifying factors, it seems quite evident that, if these labor-saving devices can be installed in a barn of reduced dimensions at a cost of less than $2,000, a cash profit is indicated. A further profit, of a more abstract nature, would lie in the more congenial type of work which would result from this system of mechanization.

It is conceivable that this mechanization could be carried to a point where it would become fully automatic, and this feature of design has not been ignored. It would involve nothing more than a system of interlocking electrical circuits which would carry through an entire feeding cycle when once started by a manually controlled switch or a time clock.

We believe, however, that animal life, subject as it is to illness, dietary upsets, weather changes, etc., is such that it requires some of the operator's time for careful observation of animal condition. During this same time he can easily start the various phases of the feeding cycle, making any minor change that animal condition indicates is necessary.

# Agricultural-Engineering Problems in Watershed Planning

By A. W. Zingg
MEMBER A.S.A.E.

I WISH to express some thoughts concerning the utilization of our resources in the humid agricultural regions, centering near the location where we are meeting today. The most important resource of this Midwest region is its agricultural production. Closely allied with the sustenance of this production is the wise use of another great resource, namely, water.

In planning the use of agricultural lands and water we soon come to the realization that the two are inseparable. The agriculturist is faced with the problem of managing lands in such a way that a maximum of precipitation is utilized for crop production. At the same time he must protect them from physical damage by runoff. The engineer is confronted with the problem of disposing of and utilizing excesses of water all the way from the farm to the Gulf of Mexico. Productive farm lands also exist throughout or adjacent to the entire pathway of the drainage system. No one disputes the fact that we need a higher control of runoff throughout its entire course. Likewise, where the potentiality and demand for functional uses of water is great, it is only reasonable that provisions should be made for their development.

By the nature of his training and experience the agricultural engineer is in a favorable position to contribute to the planning necessary to adapt controls and uses of water to the primary resource of the region. I also believe he has an educational function to perform: first, to bring about a better understanding of the needs for various controls and functional uses of water; second, to define more clearly their physical limitations, and, third, to point out the conflicts which are common to various controls and uses.

Watershed planning is the development of a plan which will provide an optimum control and use of water and other related resources of a given watershed, as equitably modified to assist in meeting the needs of the primary river system to which it contributes. A watershed will be considered a headwaters tributary to a primary river system. It will ordinarily comprise a land area of a few thousand square miles.

Some of the pertinent needs of an agricultural watershed are (1) erosion controls, (2) consumptive uses of water, (3) abatement of floods, (4) land drainage, (5) public health measures, (6) recreation, and (7) a more favorable habitat for fish and wildlife.

The devices to be employed in planning are (1) conservation farming methods, (2) dams, (3) diversions, (4) drainage ditches, (5) stream rectifications, and (6) levees. These, and possibly others, must be assembled in an orderly fashion to yield controls and uses of water throughout the area as needed.

The rate of soil loss is excessive in the glaciated areas of the Midwest. The silt burden of streams is also tremendous. In general, the seriousness of this condition has been increased by more intensive cropping during the war period.

Methods for alleviating this problem are fairly simple in principle. The rolling prairie lands of northern Missouri afford a fair illustration of the needed adjustments. A considerable portion of the hill lands should be retired to hay and pasture. Other portions of them will be terraced and continue to be cropped to grain and intertilled crops under better management systems. Farm ponds will be built, primarily for the functional use of providing water for livestock. Their numbers and distribution will be such that a maximum of forage may be utilized by grazing methods.

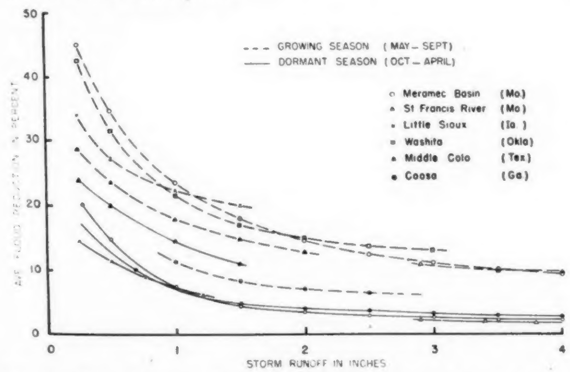
About 15 per cent of the total land area of this region is comprised of alluvial lands along numerous small streams. The abatement of storm runoff and the control of erosion will permit a more productive use of these numerous and widely distributed bottom lands. A more intensive use of bottom lands will tend to complement a less intensive use of hill lands. In many instances this is the key to the successful adoption of balanced farming systems. The complementary use of hill and bottom lands also tends to stabilize the farm economy under extremes of climate. In extremely wet years the hill lands produce abundantly, while in drought years production from bottom lands is usually capable of sustaining the farm enterprise.

We need greatly a better understanding of just what a land program will do, or will not do, in abating floods. To this end it is of interest to review the reductions determined by the U. S. Department of Agriculture in evaluating land programs for several watersheds.

The average flood reductions are of the same general magnitude as shown in Fig. 1. This reduction, in per cent, decreases with the amount of runoff. During the growing crop season, May through September, the reductions vary from approximately 30 per cent for one-half inch of runoff to about 10 per cent for a runoff as great as 4 in. During the dormant crop season, October through April, the reductions are on a lower level. For one-half inch of runoff

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946, as a contribution of the Soil and Water Division.

A. W. ZINGG is water engineer, Missouri State Department of Resources and Development.



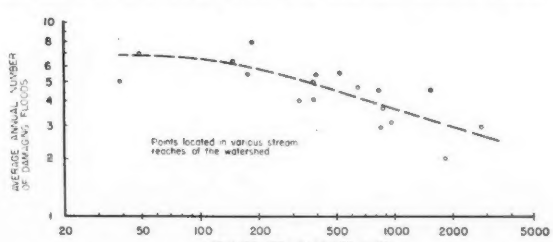




Fig. 1 *(Left)* Average flood reductions determined for land programs by various flood control surveys • Fig. 2 *(Right)* Frequency of damaging floods on the Meramec Basin

they are about 12 per cent and decrease to approximately 2 per cent for a runoff of 4 in. As would be expected, the reductions determined for the southern part of the United States tend to show less contrast for the two seasons represented. Those for the watershed of the Little Colorado River, in Texas, are not substantially different for this breakdown by seasons.

Other factors being normal, the frequency with which flood plain lands are damaged by overflow varies with the size of the contributing watershed. This fact is illustrated by the results of a recent study of the Meramec River watershed in eastern Missouri. The average number of outbank flows on various reaches of this watershed are shown in Fig. 2. In this instance, the stream channel capacity is exceeded about six times annually on drainage areas of 200 square miles or less. The frequency of flood plain inundation decreases progressively to less than three times a year at a point draining 3000 square miles. It is interesting to point out that the flood plain of the Missouri River drains an area of about 500,000 square miles and is flooded, on the average, about every other year. This condition would be represented closely by projection of the curve of Fig. 2.

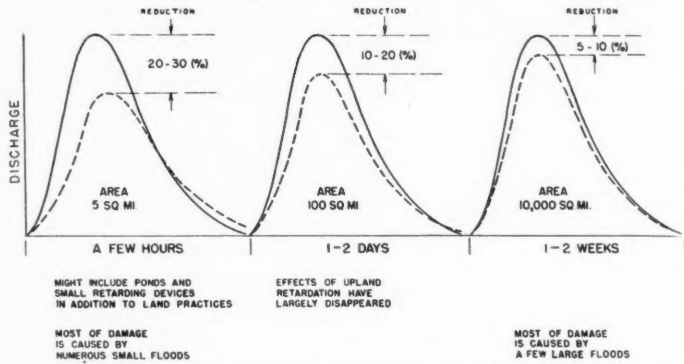



Fig. 3 This shows average abstraction and retardation of flood runoff by land practices

Many of the storms causing floods on small areas of a few square miles are intense, of short duration, and local in extent. They are also most likely to occur during the growing crop season, at which time they can be greatly reduced by a land program. Many of them do not, however, produce a flood at downstream points. As the size of the drainage area increases, a more widespread and prolonged storm condition is required to produce a flood. Runoff from this type of storm will, in general, be reduced less by a land program. Under extreme conditions reductions will be limited to the increased holding capacity of the soil and the increased evapo-transpiration afforded by better plant cover. This quantity may further be of small moment during the dormant crop seasons.

The effectiveness of a land program with increased drainage area is very difficult to evaluate. This is due largely to the fact that stream flow records are usually available only on land areas draining several hundred square miles. The floods at such points are the result of rainfall varying in distribution and time occurrence on a variable land complex. They also reflect the orientation and hydraulic properties of the drainage network. Based on a consideration of these factors, and the data given in Figs. 1 and 2, the author has attempted to estimate the general amount of these reductions on drainage areas of varying size. Such average estimated flood reductions are represented by the hydrographs of Fig. 3.

Flood damage ordinarily starts on drainage areas of 3 to 5 square miles. The flood hydrograph from an area of 5 square miles may be considerably altered by land practices. Not only will runoff be abstracted from the flood but the peak rate may be reduced and delayed by the retarding action of better vegetal cover, terraces, and farm ponds designed for the purpose. The combined effect of these measures can reasonably be expected to reduce the peak of the average flood by 20 to 30 per cent.

As runoff progresses to a point draining 100 square miles, the decrease in flood heights through flow retardation by land practices has largely disappeared. The peak may be somewhat delayed but this factor becomes inconsequential in relation to the time base of the hydrograph. Reductions will be in the neighborhood of 10 to 20 per cent.

The flood hydrograph from a 10,000 square mile area will in general be reduced by the capacity of a land program to abstract precipitation from a few floods. They usually occur during a prolonged wet period after land practices have lost much of their effectiveness. Modification of the hydrograph by flow retardation of a few minutes or a few hours near the source of runoff also becomes unimportant. The shape of the flood becomes rather a function of the channel system. This fact is the basis of the unit hydrograph concept which has in the past been widely used in flood analysis. Average flood reductions which can reasonably be credited to a land program on an area of this size would range from 5 to 10 per cent.

On small upland areas, a land program, including ponds and small storage devices for beneficial local uses, will often provide the only management of runoff which is feasible. While reducing flood peaks by an average of 20 to 30 per cent, flood damage to crops can often be reduced by 30 to 40 per cent. These practices are also estimated to be capable of decreasing the silt burden of small streams by 40 to 60 per cent. Such controls and uses of water are beneficial to all downstream points and have no conflict with any other conceivable control or use.

As the size of the watershed increases beyond a few hundred square miles, the control will, in general, fall short of the degree of protection desired. Several devices may be used at such points to yield additional flood protection. They may consist of channel rectifications or dams. Here we immediately have a conflict of interests as protection can be gained at one location only at a sacrifice in another location. If the stream channel is straightened, the floods and attendant debris are concentrated on downstream points. If a dam is built, a considerable amount of land must be sacrificed for the protection of lower lands.

Our experience with stream straightening in northern Missouri, with which I am most familiar, has not been satisfactory. While it is now yielding temporary relief from flooding to some areas, it has resulted in the abandonment of others. Where the grades are excessive, some of the ditches are tending to go out of control and to consume the adjacent lands they were intended to protect. Others cannot be maintained due to excessive siltation. At some future time it may become feasible or necessary to provide for their stability by the use of regulated flow from reservoirs or retarding basins. A land program to reduce sediment production would often be a prerequisite to any such plan.

When reservoir sites are available on areas of a few hundred square miles, several of them may be used to supplement land programs to give reasonable protection to the lower portions of a watershed. If additional protection is needed, it can often be provided with levees. Most studies

indicate that best results would be obtained by manually regulating the flow from such reservoirs. A part of the run-off into them would be stored and released as rapidly as the channel system would permit. An operating system would also have to be devised to safeguard the structure rather than the lands in the event of a great flood. In general, dams of this type may be desirable if the lower laying flood plain has a greater land capability than the lands which must be sacrificed for reservoir use. At best, they are difficult to justify economically under existing conditions of agricultural development in this region.

This type of dam has limited multiple-purpose uses. In addition to flood control, desirable uses are recreation and small releases for stream pollution and malaria control. Only in rare instances can hydroelectric power be developed on prairie land streams. A more economical type of installation is needed greatly for relatively small tributary dams. While they must be safe from an engineering viewpoint, a more efficient and economic outlet and spillway design is needed to adapt them to agricultural watersheds.

### ALL WATER-CONTROL DEVICES ARE EMPLOYED TO GAIN AN OPTIMUM USE OF BOTTOM LANDS

So far we have discussed a few of the problems of water control and use relevant to the local watershed. In planning, all devices are employed to gain an optimum use of bottom lands throughout the watershed. The adoption of plans for this purpose would have very little effect on Mississippi River floods. High river stages last for weeks or months. They result from a widespread storm condition which ordinarily continues after the capacity of the soil to store water is largely exhausted. Reservoirs designed and operated for local flood abatement will not hold runoff for a sufficient time to appreciably modify a great river flood. We should also remember that the largest flood of record on the Missouri River came in 1844. Further, we cannot restore the water-holding capacity of the land complex which existed at that time.

At the present time the storage of water for Mississippi River flood control and navigation release is being contemplated in multiple-purpose reservoirs in agricultural watersheds. It is sufficient to say that much opposition has resulted. Naturally, the use of lands for this purpose is in direct conflict with their utilization for agricultural purposes locally. In the watershed they would normally occupy more land than they would protect. At the same time they would be located below other lands needing flood protection. In many cases we do not know the land capability of either the lands to be inundated or protected. This has not been determined. Again, they may preclude the building of lesser dams at upstream points by removing the source of benefits necessary to justify their construction. In many cases we do not know if an alternate plan for local protection is feasible because such a study has not been made. In short, river controls and uses are not being incorporated into watershed planning.

In a few agricultural watersheds it is possible that a thorough study of alternate plans will show that large storage units can be incorporated without undue local sacrifices. In this event, the actual needs of present river development should govern their construction. It is of interest to review briefly the course of river development leading to the large multiple-purpose reservoirs of today.

The first levees were built on the Mississippi River for the protection of agricultural lands over 200 years ago. The great floods of 1749-50 caused widespread damage throughout the valley and the Congress directed the Secretary of War to prepare plans for flood prevention and navigation improvement. In general, river development has been a function of the Corps of Engineers since that time. In the main, improvements for flood control have consisted of raising the levees higher and higher to provide an increasing degree of protection to the 20 million acres of the alluvial valley. After the flood of 1927, definite plans were made to provide adequate floodways and backwater areas to lower flood heights. This plan was obdurately opposed by residents of the valley and the major portion of it was later abandoned. About this time numerous cutoffs also were made to improve the channel for navigation purposes.

The great flood coming out of the Ohio River in 1937 again demonstrated that existing river controls were inadequate. At that time it was believed that the levee system was about as high as could be built and maintained. It, therefore, seemed that the only recourse lay in further channel improvement and the construction of reservoirs on the tributaries. In 1938, the general comprehensive plans for flood control and other purposes—as set forth in Flood Control Committee Document Numbered 1, Seventy-fifth Congress, first session, with such modifications thereof as in the discretion of the Secretary of War and the Chief of Engineers may be advisable—were approved for the Ohio, upper Mississippi, Missouri, White, and Arkansas River basins. This included a blanket authorization for a large number of reservoirs, many of which were designed for flood control on the main stem of the Mississippi River.

By 1941 it became apparent that flood stages on the Mississippi River had been lowered appreciably by completion of the 9-ft navigation channel and shortening of the river by cutoffs. At the same time, experience in levee building coupled with rapid advancements in the science of soil mechanics also made it possible to increase the height of levees.

Most of the reservoirs authorized in the Missouri River basin for Mississippi River flood control in 1938 were reauthorized in 1944 as set forth in House Document 475, Seventy-eighth Congress. This was a comprehensive plan for the Missouri River basin. Many of them were, however, enlarged for multiple-purpose uses. In the main, this consisted of adding storage for navigation release.

### GREATEST PROBLEM WITH MISSISSIPPI RIVER IS STABILIZING EXISTING SYSTEM OF CONTROLS

At the present time the greatest problem concerning the Mississippi River appears to be that of stabilizing the existing system of controls. Straightening of the channel has accentuated its tendency to meander by caving its banks. Funds were authorized for such stabilization in the 1944 Flood Control Act. The situation is well described in a report of the Mississippi River Commission: "The Commission is of the opinion that stabilization of the river is necessary in order to retain reduction in flood heights obtained by channel rectification, and is advisable for the purpose of safeguarding the main Mississippi River levees and protecting the investment which they represent. The Commission is of the further opinion that such stabilization may materially increase the flood-carrying capacity of the river channel and together with the maintenance dredging already authorized, will provide a minimum depth of 12 ft at low water for navigation. . . ."

No one questions the need for adequate flood control on the Mississippi River. The capacity of the river, however, has been increased greatly by the works of the last decade. All indications are that the present program of stabilization and navigation improvement will add a further factor of safety. Backwater areas along contributing streams in the lower valley are also being rapidly eliminated by additional levee construction. In all, it seems reasonable to assume that probabilities of large *(Continued on page 410)*

# "Industry Requirements of Professional A-E Education"

TO THE EDITOR:

IN THE issue of AGRICULTURAL ENGINEERING for December, 1945, you published the above-titled report of the Subcommittee on Industry Requirements of the A.S.A.E. Committee on Curriculums, which prompted me to ask this question of representatives of companies employing agricultural engineers, with whom I was in contact in connection with committee work in the A.S.A.E. and Farm Structures Institute: "What are your ideas as to desirable qualifications of agricultural engineering graduates and methods of training them?" Some interesting replies were received.

Since my chief interest is in the field of farm structures, most of the replies are from basic building materials manufacturers or associations of such manufacturers. However, two replies came from leading farm equipment companies; one of them contained these comments: (1) Practical experience for students is needed, especially during summer vacations; (2) training should emphasize development of the arts of thinking and persuasion; (3) training should emphasize development of fundamentals of good personality, correct attitudes (courtesy, diplomacy, willingness to work, need for continued study), and good habits (accuracy, thoroughness, honesty, initiative, etc.).

These comments constituted the reply from the second farm equipment manufacturer: (1) Students should come from the farm; (2) good basic, but fairly general, agricultural courses are best — election of a major is not so important; (3) versatility is important—our company trains beginning men in its particular problems and policies, thus fitting them for various company jobs.

One building materials manufacturer says: "Practical experience (12 months, post-graduate) should be required; it is what is most lacking in present graduates," while another has these comments: (1) Present curriculums cater more to teaching and extension than to industry requirements; (2) colleges should become more keenly aware of the need for high professional standards in the structures field, and of opportunities therein for good men.

Comments were obtained from three associations in the building materials field. The first offered the following: (1) Men of better training are needed — there are too many so-called agricultural engineers who really aren't, to the detriment of the profession; (2) a four-year course is none too long; (3) a knowledge of functional and structural requirements, materials, design, etc., is needed; (4) teaching personnel needs improvement. The second association commented as follows: (1) Present graduates lack knowledge of structural design and materials — there is a real lack of adequately trained structures men; (2) students should elect a major and specialize earlier in the course. These comments came from the third association: (1) Graduates should have more training in speaking and writing as well as technical training; (2) a farm background is highly desirable; (3) good personality and attitudes, a willingness to work, are important qualities.

A building materials manufacturer made these comments: (1) More competent instructors are needed; (2) many openings for well-trained structures men now exist in industry.

The foregoing comments, plus considerable interchange of ideas among industry people who are present or potential employers of agricultural engineers (again principally structures men) provide the basis for the discussion that follows:

It is probable that the majority of agricultural engineering graduates who replied to the questionnaire distributed by the A.S.A.E Subcommittee on Industry Requirements were in the category of employee rather than employer. The reverse is true of a majority of those who made the comments listed above. Among them are some who have had unfortunate and disappointing experiences with newly employed young agricultural engineers and others who have sought vainly for men who were acceptable.

In the main, there is agreement with the subcommittee report as published in AGRICULTURAL ENGINEERING. Uniformity of curriculums is of great importance. *How* a student is taught is fully as important as *what* he is taught.

Everyone values highly such qualities in graduates as pleasing personality, efficient habits, ability to think constructively, possession of good character and cooperative attitude, regardless of whether the man's inherent abilities and tendencies or his college training have contributed most to these. The curriculum and the instructor should be chosen to provide the maximum possible of training and inspiration along liberal lines, without neglect of the completeness of engineering instruction which the engineer in today's competitive world desperately needs.

*Specialization Necessary for Some.* Not one but several kinds of graduates are needed. Industry needs, for example, men for sales and sales promotion work. They should be especially adept in speaking and writing. Industry needs also technical men for research and the services. They should definitely be specialists in farm machinery, structures, soil and water, or electrification.

There is as much range of subject matter in agricultural engineering as there is between architectural, mechanical, civil, electrical, and chemical engineering. The field of farm machinery is largely mechanical engineering; the field of farm structures, architectural and civil; the field of soil and water, civil; the field of farm electrification, electrical.

It is as impossible to train men adequately in all phases of agricultural engineering simultaneously, as it is in all the other phases of engineering combined. The field is so large that too much generalization is apt to produce inferior men not well equipped in anything.

Some of the relatively large companies engaged in the manufacture and distribution of equipment or materials solely or almost entirely for the farm market can and do take graduates of a "general" course and then teach them "specialization" in a particular phase of agricultural engineering in conjunction with a period of or course in orientation.

But the many and various firms, only a part of whose products find their way to the rural market. usually require some specialization and are not particularly interested in other phases of agricultural engineering than their own, except in a general way. *A specialized training superimposed upon a farm background is needed to provide the right kind of men for these jobs.*

Unless we have "farm structures engineers," "drainage engineers", etc., instead of merely agricultural engineers who are the product of a general course, many firms will hire architectural and civil engineers and will perhaps employ only one agricultural engineer having general training to set the requirements as related to agriculture. In fact, these agricultural requirements might even be supplied by crops and animal husbandry men instead of by agricultural engineers.

*Standard Length Terminal Course.* It is somewhat difficult to reconcile the statement in the subcommittee report that "A four-year terminal course is believed preferable to a longer training period if students are to be attracted and held in sufficient numbers", with a following suggestion that, where faculty and facilities permit, educational institutions establish graduate work for "highly specialized jobs in industry" and other work. Many of the agricultural engineering jobs in industry (the *engineering* jobs) are "highly specialized". More of them would be if properly trained men were available. While sales or sales promotion work may not always require specialization, it is also true that for most of the graduates, especially in the structures field, a more specialized training in their particular field of interest is the key to their professional success and the healthy growth and recognition of the profession generally.

The report states that there should be "a thorough preparation in the fundamental sciences" rather than "a smattering of fundamentals and specialized knowledge." That is exactly what the highly specialized jobs in industry require. However, rather than to require of most students an extra year of graduate work for such instruction, could we not offer *some* of our students a thorough preparation in all of the fundamentals of *one* of the major branches of endeavor rather than a smattering of knowledge of each, and could it not, perhaps, because of a greater singleness of purpose, be done in four years? There is an unquestioned need for some post-graduate instruction, but a four-year terminal course that will provide a satisfactory training in the chosen field of interest is the need of the majority. It should be of equal length for all, regardless of choice of major interest, and the same length as for other branches of engineering.

*About the Curriculum.* Industry thinks that we need perhaps optional but at least recommended and guided specialization in the junior and senior years of an agricultural engineering curriculum. We need, for example, structures graduates who:

1 Have sufficient knowledge of basic materials to use properly new combinations of them for improvement of structures

2 Know functional requirements of farm buildings

3 Are thoroughly grounded in heat transfer, vapor problems, animal metabolism, etc. (Perhaps this requires work in mechanical engineering)

4 Are thoroughly grounded in ventilation

5 Are thoroughly grounded in structural design. (Perhaps this and the following point require work in architectural engineering)

6 Are capable designers from the esthetic angle

7 Are taught by competent structures men.

The specializing "channel" may be farm machinery, soil and water, electricity, economics, journalism, or "general".

Such specialization would usually mean a more thorough preparation of students in certain *selected* and *packaged* "basic engineering courses which are fundamental to agricultural engineering", to quote the subcommittee report, of which *(Continued on page 428)*

# Stream Bank Erosion Control

By H. H. Lester
MEMBER A.S.A.E.

IN THE southeastern part of the United States there exists a continuing challenge to engineers and others interested in soil conservation, to do something about the yearly ravages of streams flowing through agricultural lands. This is particularly true in those areas of loessial or alluvial soils that yield quickly to flood forces in the stream channel. The caving of stream banks is responsible for the loss of many acres of good cropland each year.

In dealing with this problem from the standpoint of individual landowners, only small streams, creeks, and branches are considered in this discussion. Larger streams or streams affecting several landowners are usually considered to be "community" problems. While the same methods of control herein discussed are believed to be adaptable to these larger streams, they have not been tried extensively enough to afford definite information.

Accepting its share of responsibility in meeting this problem, the Soil Conservation Service working through the soil conservation districts has undertaken to assist landowners in developing a clear understanding of the factors involved in stream-bank control and in making plans to do something about it. Numerous locations have been studied, plans made, and protective measures installed. Soil conservation districts are primarily interested in the protection of the watershed itself. This means maintaining the soil in its present position and keeping as much of the precipitation as possible in the soil on which it falls. Its efforts have therefore been directed, first, to the land itself and, secondly, to the drainage channels carrying the surplus water from the lands.

Stream-bank protection work has as its aim the stabilization of the bank through use of vegetation. Frequently it is necessary to use mechanical means to protect these plantings during their establishment. Major changes are generally not made in the location of the channel, but rather the banks are stabilized in place. Observations of these conditions and experience in dealing with them has indicated that a stream channel of adequate capacity, amply protected by the right kind of vegetation, is the simplest insurance against stream-bank caving. The ideal situation is where the normal flow is directed through a stable channel bordered by low banks over which the flood flows can spread without overtopping the high banks which define the permanent stream. This is illustrated in Fig. 1.

*Factors to be Considered.* Several factors influencing volume and rate of concentration of flood flows are size, topography, stream pattern, and land use of the drainage area. The size and topography of the drainage area can be determined from maps available to the soil conservation district. The land use can be determined by a reconnaissance survey or aerial photographs. It is also advisable to question the landowner or some old resident of the neighborhood as to the past behavior of the stream and the seriousness and frequency of floods. Drift and debris give evidence of high water levels.

Other factors to be considered include stream gradient, physical makeup of stream channels, especially "sand bars", vegetation or lack of it, and the rate of bank cutting.

Changing the stream flow in one section of the channel will have a decided effect on the flow for some distance down stream. These resultant effects must be considered, especially when the channel is forced into a new location, or when the stream forms a property boundary.

*Protective Measures.* For the purposes of this paper, stream bank erosion control will be treated under three major headings: (1) mechanical control, (2) vegetative control, and (3) maintenance.

1 *Mechanical control* will be considered as a preliminary step toward the establishment of permanent vegetation, and in most cases it will be assumed that the mechanical structures will sooner or later disappear after they have served their purpose in aiding vegetation to take over.

Due to the various and different conditions encountered along eroding stream banks, it is necessary to consider two types of structures — timber jetties and rock jetties.

In the past many attempts have been made by engineers and contractors to prevent the caving of stream banks by the use of piling driven to form jetties, dykes, deflectors, or wing walls. Usually the pile structure is completed by the

This paper was presented at the meeting of the Southeast Section of the American Society of Agricultural Engineers at Birmingham, Ala., February, 1946.

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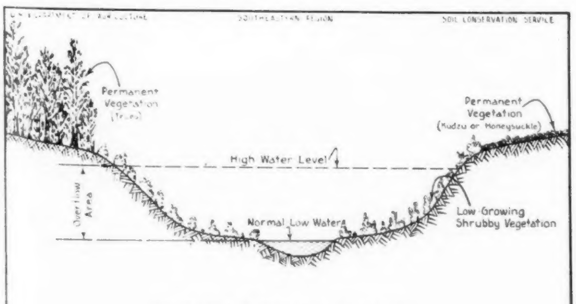
AUTHOR'S NOTE: Recognition is given to L. B. Morehead, former area engineer, Soil Conservation Service, and to his associates who furnished much of the material for this paper, and who, during previous years, established many stream-bank protective works.



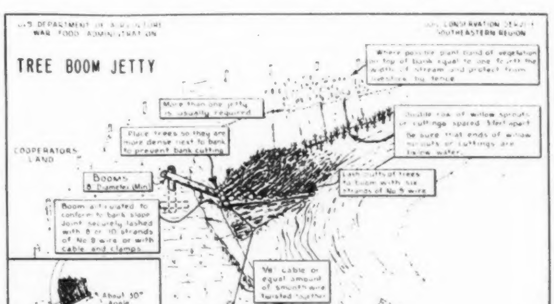




Fig. 1 *(Left)* Desirable stream channel cross section • Fig. 2 *(Right)* Tree boom jetty, showing location and construction details

use of boards to form a deflecting wall, with the entire unit braced and anchored to form a rigid structure. While this type of bank protection has its place in engineering works, it is usually expensive to construct and difficult to maintain. Furthermore, it requires pile-driving machinery and other heavy equipment. Since in this discussion the primary interest is in some simple, inexpensive structure that can be installed by farmers, and with farm equipment, the driven-pile structures are eliminated.

The tree jetty — a flexible, articulated, mass of small, ordinary woodland trees — is simple to construct, inexpensive, and easy to maintain during the few years of its life. The design of the tree jetty has been so simplified that the farmer has to make no outlay of cash for anything except some old, discarded steel wire cable for anchorage, and for some smooth wire for tying the trees together.

The trees are lashed at the butts to a boom which projects from the bank. The boom is securely anchored to the bank by cable and "deadmen". The tree tops float downstream. Farm labor and the farm tractor provide the material and do the work.

The details of construction are shown in Fig. 2.

In areas where timber is not easily available, but where rock is plentiful, it may be necessary to resort to the rock jetty. This type of structure is not expensive but requires a considerable amount of rock which may have to be hauled some distance, and also requires a little more labor and wire. This structure is a simple woven-wire stocking, 4 or 5 ft in diameter and filled with rock, laid so as to project into the stream. It is built in place and the bank end securely anchored to a deadman.

2 *Vegetative control* is the ultimate aim in stabilizing eroding stream banks. If vegetation can be securely established without the aid of structures, so much the better, but when jetties are used, advantage must be promptly taken of the temporary protection afforded for the establishment of vegetation.

Vegetative plantings are considerd in two main groups — those placed on top of the bank and those placed at the bottom of the bank.

A band or border of trees or shrubs should be provided and maintained along the stream bank in order to give protection against cultural encroachment too close to the top of the bank. Through cultivated fields, kudzu or honeysuckle is very beneficial, while through wooded areas, ordinary woodland plantings should be made or existing stands protected.

The more important plantings are those at the bottom of the bank where the erosion begins with undercutting, causing caving and sloughing. The type of vegetation used here must be selected for its strength and vigor, and its ability to resist scour, and also for its rapid growth. A securely rooted shrub or vine, or tree species such as willow, cottonwood, or "water" birch, kept cut back, is desirable for planting at the foot of the bank.

It must be kept in mind that stream-bank control does not mean the restricting of the channel, but rather the stabilization of the banks after an adequate waterway has been provided.

Plantings should be made as close to the water's edge as possible, provided there is one to two feet of sand, silt, or mud above the low-water level in which the willow cutting can take root. Cuttings may be made during the winter and early spring, using only bright yellow or green branches and placing immediately. Cutting should be five to eight feet long and from one to four inches in diameter. This size is necessary in order that they can withstand the flood stages, drift and weed competition. Cuttings can be rooted in sand, if time permits, and they can be planted with roots attached.

Holes are made with a crowbar or posthole digger, and cuttings should be planted three or four feet deep. Plantings are extended back from the water's edge as far as desirable, provided the lower end of the cutting is in moist soil. Spacing should not exceed six to eight feet. Small willow logs, partially buried with the lower end in the water, are satisfactory on sloped banks. Logs are spaced four to six feet apart.

Supplementary plantings of locust, walnut, sweet gum, or sycamore may be made in adjacent overflow areas (Fig. 1) but these species should not be used along the water's edge.

Plantings should be protected from livestock, and where necessary, temporary fencing should be constructed until trees have reached a size that will obviate the need of further protection. This period will be at least five years.

Foresters and biologists should be consulted in regard to technical problems in their fields as they relate to the job. The shrubby vegetation in the overflow channel affords excellent wildlife shelter.

3 *Maintenance* of stream-bank protective vegetation is of great importance. All too frequently the established plantings are neglected and allowed to grow too rank or too large, thus obstructing the stream flow; or they are damaged by grazing or fire.

Shrubby vegetation at the foot of the bank will need little maintenance but tree growth there will need to be cut back from time to time. This is much easier done by annual maintenance than after waiting several years until the trees have grown to objectionable size. Do the job of maintenance when it is needed.

Fig. 3 *(Left)* Close-up view of jetty construction • Fig. 4 *(Right)* Relative position of jetties

Fig. 5 *(Left)* Silt depositing behind jetty, four months after construction • Fig. 6 *(Right)* Silt caught by jetty helps anchor the structure

*Use of Structures.* The logical and economical use of structures for stream-bank protection appears to resolve itself into two main classifications: (1) To protect an eroding bank and maintain it in its present location, and (2) to force the channel away from the eroding bank by scouring out a new channel through the sand bars on the inside of the curve.

1 When the stream bank is to be protected and maintained in place, such as along a property line, the establishment of protective vegetation is begun by the use of a mat which embodies live willow poles. These poles take root and grow in place. By timely cutting back, they sprout new stems and thus increase the density of growth.

Willow mats should be built during the time of year when the willows are dormant. The eroding bank is graded down to about a 45-deg angle. Willow (white, salix alba, if possible) poles of any diameter are laid on the sloped bank and placed about one to two feet apart. These poles have all limbs removed so they will lie flat and be in contact with the ground. The butt ends are shoved well down into the water. These poles are covered with brush of any kind, the bushy tops of which are alternately placed at the top and bottom of the bank. When a mat about 6 in thick is in place, it is covered with old woven wire laid in horizontal bands and laced together with wire. To hold all this material in place, stub posts are set eight feet apart along the top of the bank. Heavy stone weights are laid on the mat at low-water mark and attached to the stakes by long wires. The wires, extending from the posts at the top of the bank down over the mat to the weights, hold mats in place during heavy floods. This has proved to be far superior to stakes which loosen and come out during wet times.

When spring comes the willow poles send roots down into the moist soil on the bank, and in a few months a dense growing mat is obtained. This method has the disadvantage of requiring a large amount of brush, and a considerable amount of labor.

2 The most common problem in the control of erosion along streams through agricultural land is in connection with bank undercutting and sloughing on the outside of bends. Usually this undercutting and sloughing is accompanied by the formation of a bar on the opposite side of the stream. The job therefore is to move the channel of main flow away from the eroding bank and cause it to encroach on the sand bar side.

To establish vegetation on the sheer, bluff bank is extremely difficult because there is no planting area. It is first necessary to cause some deposits of sand and mud to form at the foot of the sheer bank. This is expedited by the use of mechanical structures placed at strategic points, which give temporary protection to the bank and at the same time sufficiently retard the current to cause sand and silt which is carried in suspension in the water, to drop out. Each successive high water adds material to this deposit until a bar is formed behind the structure.

The structure is usually a timber jetty such as was mentioned earlier in this paper. The location and construction are illustrated by Figs. 2, 3, and 4. Usually more than one jetty is required, and the series of structures should cover the entire bend of the stream. They are placed close enough together to be sure that the effects from the tail end of one reaches to the head end of the next one below. This spacing can be determined by field observations and a general knowledge of the stream flow conditions.

The angle of projection and the length of the jetty are important factors to be considered. The farther a structure is projected into the stream, the greater the scour off the tail end becomes. However, there is a practical limit to the amount of this projection. A jetty with too great a projection causes the structure to act as a dam. Due to the restricted effective channel, the stream will overflow its banks. This restriction also increases the velocity off the end of the jetty to the point where serious undercutting of the toe takes place and endangers the stability of the jetty. Experience in the field indicates that the proper projection is 30 to 40 per cent of the stream width at flood flow, contingent upon the size and type of watershed, cross section of channel, and flood stage.

The best angle of projection is 45 deg with a minimum of 30 deg. This angle of set produces the maximum deposition above and below the jetty on the outside of the curve. This deposition is quite important because it creates a suitable site for vegetative plantings.

The best location for the jetty to cause sand bar cutting is at the upstream end of the bar. The spacing of these jetties depends upon the physical make-up of the sand bars, frequency of floods, volume of water carried by the stream, and the radius of curvature. For example, the jetties can be spaced farther apart if the sand bars are made up of fine sand, if the stream has frequent floods, carries a large volume of water, and the channel has an 800-ft radius, than if the bars are made up of heavy gravel, the stream has infrequent floods, and carries a small volume of water, and the channel has a 200-ft radius.

Jetties should be keyed well into the bank. The exact distance depends on the length of the jetty, height of bank, types of soil in banks, and size of stream, roughly from 5 to 20 ft.

Just as soon as a sufficient bar has formed in front of or behind the jetty, the placing of rooted willows can be begun provided there is sufficient water to keep the roots wet.

By the time the temporary structure has decayed and disappeared, the growth of willows should be sufficient to give adequate protection against a recurrence of the bank erosion, caving, and sloughing that set up the original problem.

*Typical Example.* During the past year a stream-bank job was undertaken in northern Mississippi along a creek that was taking a heavy toll of good soil each year. During the previous season the farmer had made a bale and a half of cotton per acre in the bottom fields along this creek. The loss of great blocks of this valuable soil by creek bank caving caused him to want desperately to do something to save his field. Accepting the plan for tree jetty construction as shown in Fig. 2 (with minor modifications in anchorage) he installed five structures around the curve in the creek as shown in Fig. 8.

Using his farm tractor and timber cut from his land near the creek, this farmer with the help of four hired men constructed one jetty per day. The only cash outlay was for second-hand cable to use as anchorage. He plans to continue similar jetty construction around other bends in the creek during this winter season.

The effectiveness of this type of bank protection is shown in Figs. 7, 9, and 10. The jetties were built in February, 1944, during low water. Following a series of high-water stages during the next three months, a two to four-foot deposit of silt and sand had accumulated, as shown in Figs. 5 and 6, and the stream current had been forced out from the bank to the end of the jetty. Almost simultaneously willow sprouts began to grow on these newly formed bars. During the dormant season additional plantings will be made to hasten the effectiveness of the protection afforded by the vegetation. By the time the jetties have decayed and disappeared from the site, the willow thickets along the bank will be large enough to give lasting protection against further cutting and caving of the stream bank.

## Problems in Watershed Planning

*(Continued from page 405)*

flood damage have been greatly decreased in the last decade. Yet, benefits claimed for water to be stored in tributary reservoirs for Mississippi River flood-control purposes have not been revised to meet this changing situation. It seems that such benefits should be thoroughly reviewed with respect to the conditions which now exist or will attain shortly.

It is obvious that the development and stabilization of a 12-ft navigation channel on the Mississippi River would be compatible with flood protection to the Delta area. It should, however, be pointed out that this channel would require additional water to supplement low river flows for navigation. Deficiencies already exist on a 9-ft channel. Furthermore, all the reservoirs now authorized for construction would not be capable of eliminating the present deficiency.

If river transportation develops in accordance with the beliefs of the proponents thereof, there will be a greatly increased demand for navigation reservoirs in the future. This development would be in direct conflict with uses of water for irrigation in the arid portion of the Missouri Valley, and also with the agricultural use of productive lands in humid regions of the Midwest.

Fig. 7 *(Upper left)* Low flow channel has been forced away from sheer bluff bank, six months after construction • Fig. 8 *(Upper right)* Panoramic view of five jetties protecting one bend in the creek • Fig. 9 *(Lower left)* Jetty partly buried in silt, and vegetation growing, one year after construction • Fig. 10 *(Lower right)* Ledge at foot of bank for planting erosion-resisting vegetation

# Flame Cultivation and Other Mechanization of Cotton in the Yazoo-Mississippi Delta

By Thomas L. Baggette

FOR many years the Delta has recognized the necessity for using tractors and tractor equipment in many of its farm operations. Land has been broken and crop "middles" — those stretches of land between production rows — cultivated by machine. It was in 1944 that the state of Mississippi, recognizing that the only solution to the problem of an ever-decreasing labor supply on the farm lay in total mechanization of farm operation, appropriated $30,000 to the Mississippi Agricultural Experiment Station to study the mechanization of cotton and other crops. Dr. Clarence Dorman, director, designated the Delta Branch Station at Stoneville to conduct these studies.

Mechanized farming implies the use of machines wherever and whenever possible to fill the gap due to the lack of hand labor, whether it be in the harvesting of corn with a corn picker, the picking of cotton by machine, or the controlling of weeds and grasses in a crop row by the use of flame. Cotton up until this time has required more hours of hand labor than any other crop grown in the Delta[1]. The constant exodus of labor from farm to city, out of the Delta, and from the southern agricultural section as a whole, has increased the problem of maintaining production with the old hand methods of farming and similarly increased the need for mechanization of cotton production.

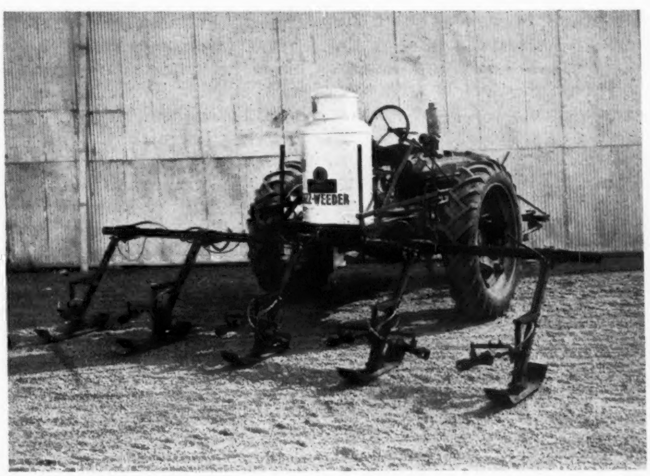
Any individual or family can produce more cotton than it can pick. This results in the landowner having to take responsibility for picking the excess crop which is costly to both owner and tenant. The development and perfection of the spindle-type cotton picker to the point where it is a reliable farm implement completely changes the labor balance in cotton production. It has been pointed out[2] that, if the picker is used to harvest more than this excess production, labor will then have to be subsidized for production instead of for harvesting. Further, it would seem that greatest economy in production depends on complete mechanization of the whole of the crop rather than a part. Although processing of cotton is done mechanically, mechanical harvesting creates many problems yet to be solved if mill equipment is not to be overtaxed, and/or lower grades result for the producer.

Some plantations in the Delta have, for years, made use of every power implement available for cotton production. In fact, more and more responsibility has been assumed by the owner until, in many cases, preparation of land, planting, and cultivation of the crop has been done by him rather than the tenant. The need has remained, however, for a certain amount of hand labor in crop production. The amount varies with the type of operation, i.e., whether the planting is by drilling, checking, or hill dropping.

It was not until use was made, in 1943, of the "flame cultivator" in cotton production[3], that an approach to complete mechanization seemed possible. In spite of the fact that the cotton had been thinned, hoed twice, and cultivated twice, continued rainy weather had caused excessive growth of grass — so much so that the cleaning of adjacent areas with the hoe cost $10 per acre. The cotton was cleaned successfully by means of flame and kept clean until the end of the season. No reduction in yield was found as compared with areas continued to be handled by regular plantation methods.

The term "flame cultivation" is relatively new in agriculture. It is a process patented by Price McLemore of Waugh, Ala., and licensed under the Fijelen Research and Development Co. of Washington, D. C. This process promises to be an answer to hand chopping, and to eliminate to a great extent hand hoeing of the cotton crop from the time the stalk of plant is 3/16 in in diameter until it is "laid by". With the realization that the 20-spindle-high International mechanical cotton picker is no longer an experimental farm machine, the problem of seasonal labor for cotton production has been reduced to one of weed and grass control. Tests at the Delta Station indicate that the flame cultivator is the only answer to the problem, to date, beyond labor economy attained by cross cultivation. Certainly the flame cultivator is a farm implement of interest to the agricultural engineer.

The flame cultivator is a revolutionary new piece of farm equipment that eliminates young weeds and grass in the crop row by the process of flaming. Burners are mounted on a frame back of the tractor in a staggered pattern so that two burners flame one row, one from each side. The flame is directed




The 1946 model of the New Holland "Sizz-Weeder" mounted on a Farmall tractor. It is equipped for four-row flame cultivation and for using propane or butane fuel

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[1]Welch, F. J. and Miley, D. Gray. Mechanization of the Cotton Harvest. Mississippi Agricultural Experiment Station Bulletin 420, p. 9, June, 1945.

[2]Adams, J. E. Mechanization of Cotton Production. Sixth Cotton Research Congress, Dallas, Texas, July 1945, and Proceedings of Cotton Textile Institute, annual meeting, 1945. In press.

[3]Neely, J. Winston, and Brain, Sidney G. Control of Weeds and Grasses in Cotton by Flaming. Mississippi Agricultural Experiment Station Circular 118, March, 1944.

toward the base of the plants and extends well into the opposite middle. Burners are never set opposite each other, since this would result in deflection of flame upward and consequently scorched leaves. Flame cultivation of the crop row may be carried on simultaneously with the conventional cultivation of middles. The practice of flaming eliminates the throwing of dirt to the plant that is being cultivated, thereby permitting flat cultivation. The throwing of dirt covers weeds and grasses; but the fundamental theory of flame cultivation is to kill these growths rather than cover them. If dirt is thrown around the plant, grass cannot be reached by the flame as it passes along the crop row. Tests have shown that 4 to 8 in of row should not be disturbed by plowing, but rather be left to flame cultivation alone. On the cultivators mounted in front of the tractor, 8-in, high-speed sweeps were used for the season, except the last cultivation, which was handled by flame alone. Cultivation by flame can begin approximately two to three weeks after chopping or thinning the crop to a stand.

The International Harvester mechanical cotton picker in operation in a luxuriant growth of cotton

Chopping, or thinning, of cotton need no longer be a hand operation in cotton production, as several mechanical devices are available for this purpose, namely, the Dixie chopper, the Finklea chopper, and the flame chopper. The Finklea chopper has been found to be the best for large cotton since it will successfully thin cotton that has reached a height of 10 to 12 in, but the flame chopper appears to be best in small cotton. It consists of a wheel on which are mounted five open-end metal boxes. The number of wheels will depend on the number of rows being handled at one time, either two or four rows. As the wheels are drawn down the crop row, the open-end boxes protect the cotton to be saved as a stand, and the remainder, as well as small grass and weeds, is destroyed by flame. Cotton should be plowed once a week between this operation of chopping and the time when flame cultivation can begin. During this interim cultivation operations consist of simply plowing the middles with the regular and conventional cultivation sweeps and using the rotary hoe to handle the drill or crop row. This tool also acts as a fender and does not allow the dirt to cover young cotton. The rotary hoe, as developed at the Hopson Plantation at Clarksdale, Miss., is built in gangs of four to the row and, when drawn down the row during cultivation, takes out young weeds and grasses in the drill and does not injure the cotton plant. This is the only tool thus far developed that will handle this particular cultivation operation.

Flame cultivation has not been confined to cotton alone. Barr[4] has used it successfully on sugar cane, and Fijelen[5] reports its use on truck crops. Corn and soybeans have been flamed at the Delta station. Contemplated experiments include preflaming of seedbeds before planting and again before planted seed comes through the surface. Flame may be the answer to fallow problems, noxious weed control in oat lands, of weeds on ditch banks; and it may have sundry other uses. Tests have proven that flame can completely control weed growth in cotton except in adverse seasons.

The machine used in 1943 was a sulky-type and drawn behind the tractor; it was designed for use on sugar cane. It required one man for operation, besides the tractor driver. In addition to requiring too much space for turning, the burners did not operate continuously. As a result of experiences in 1943, the machine for 1944 was tractor mounted; automatic ignition was provided for the burners, and provision was made to raise and lower the burner assemblies by means of a power lift. The machine operated very satisfactorily with the tractor operator also taking care of the burners. With automatic ignition, attention required for satisfactory operation was reduced to a minimum.

Development of the compressor-type machine in 1945 consisted of two things: (1) provision for cultivating between the rows with simultaneous flaming of the drills and (2) extension to a four-row machine.

All machines used in 1943-45 required a compressor to furnish air for the burners which operated on either diesel fuel or kerosene. During the 1945 season, studies were started on the use of "bottled gas" in cooperation with the Fijelen Research and Development Co. and the Philgas Co. An experimental two-row machine was developed, simple in design, which duplicated the work of the compressor-type machine and operated with a minimum amount of attention. With gas under pressure, the air compressor is eliminated. Certain safety features can be incorporated not possible with the former machine.

The ultimate success of this gas-burning machine is reflected in the fact that in 1946 approximately one thousand of these machines will be built by the New Holland Machine Co., New Holland, Pa.; the Servis Equipment Co., Dallas, Tex.; and the Dixie Metal Products Co., Bessemer, Ala. These companies at the present time do not contemplate the production of any kerosene-operated machines which use the self-energizing type of burner. A majority of the machines to be built this year will be four-row assemblies. All machines will be distributed through the New Holland Machine Co., their local dealers, or other farm implement companies with which they are affiliated. There has not been developed to date a satisfactory, self-energizing burner for flame cultivators that will equal the performance of the bottled-gas machines. The bottled-gas machine is relatively trouble-free in operation, does not require the repeated adjustment in the field of the fuel and air mixture to obtain maximum kill as from flame, and is lighter in weight.

A machine was assembled this year that could operate in the field and have all the features of the oil-air machine such as a power lift, spark plugs to ignite the burners, and operating control within easy reach of the tractor driver. Butane was the first gas used and it was noted that it would not gasify in sufficient quantity to supply a two-row flame cultivator for more than two hours without the pressure dropping below that required for satisfactory opera-

[4] Barr, Harold T. Controlling Weeds by Flame. AGRICULTURAL ENGINEERING, pp. 291-292, August 1945.

[5] Fijelen Research and Development Co. Private communication.

tion. Next, a mixture of butane and propane was used, with similar results. From these tests it was concluded that, if either butane or a mixture of butane and propane is to be used, an accompanying system for gasifying will have to be added, if the fuel is transferred from tank to burner as a gas rather than as a liquid. Total consumption of burners determines the size of gasifier needed. There are several items to consider when determining the type of gas to use: Butane can be stored in tanks of weaker construction than propane, (propane gas exerts a pressure that requires, in construction, a tank that will handle pressures greater than 200 lb per sq in). Butane has 10 per cent more heat value per gallon than does propane. Consequently, if the flame cultivator has a gas-generating device to compensate for heat of vaporization, it is not necessary to consider only propane as a fuel. Cost and availability of one of the other fuels, or a combination of both, are irrelative to efficiency, machine type, and/or effect. Sufficient quantities of gas have been generated to supply burners for two rows until 10 per cent liquid was left in the tank. Using a 70-gal tank and filled to 90 per cent capacity with propane, all except approximately 10 gal was consumed before satisfactory operating pressure was lost. At the rate of 8 gal per hr, this tank could easily supply one-half day of operation. The time of filling is increased as the propane is withdrawn from the storage tank. Filling the supply tank from the storage tank is accomplished by a connecting hose; a slight difference in pressure between the small and large tanks causes the gas from the large tank to flow into the small tank when the valve is opened.

It has been observed during these studies that, regardless of the burner used, the effective width of the flame pattern is in all cases the same as the diameter of the mouth of the burner. The length of the flame is dependent on the pressure and ranges from 10 to 18 in. A driving flame 12 to 14 in long is sufficient to saturate the crop row, which is the critical point at which the flame is directed.

### FLAME CULTIVATION SIMULTANEOUS WITH CONVENTIONAL CULTIVATION REDUCES TRIPS 50 PER CENT

The results of these studies established the fact that an equal if not better job is done in killing grass, vines, and weeds when using bottled gas as when using the present oil-air flame cultivator. Flame cultivation of drills simultaneously with conventional cultivation of middles reduces by 50 per cent the number of trips necessary through a field and is, consequently, a major contribution to reduced labor, field, and cultivation costs.

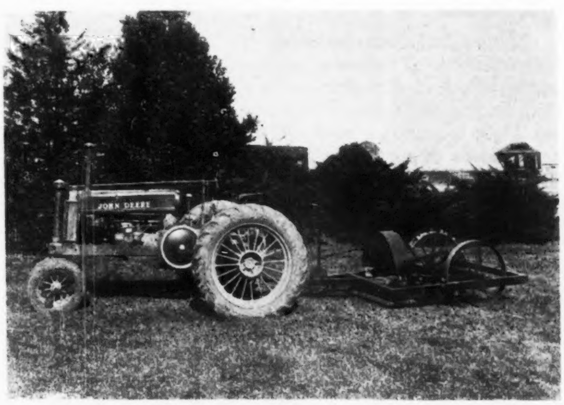
The use of skids to support the burners is the best arrangement tested. Castor wheels have been found to lock even on four-row turns and proper adjustment of burners could not be attained on a wheel-mounted machine. Ease in turning is more readily accomplished when the entire burner assembly is raised clear of the ground.

How far farm mechanization has progressed in the Delta and what the future farm operation may be is perhaps best described by a review of the five major tests conducted at the Delta station last year, and a brief summary of what is contemplated in the future. Test A was set up to study type of cotton planted and cultivation. The tests on drilled, as compared to checked cotton, were sub-divided as to defoliated and undefoliated cotton and further broken down as to kind of weed control in the row. Hoed versus mechanically blocked and flamed tests were made on the drilled cotton, and hoed versus flamed on the checked cotton. These various plots were then divided as to type of harvesting, i.e., hand picked and machine picked. This is a repetition of a test conducted in 1944[2,6]. Test B included three different varieties of cotton and nine different methods of picking. Test C involved nine varieties of cotton, defoliated and undefoliated, hand and machine picked. Test D was a seed cotton cleaning test on three different varieties, all plots defoliated and machine picked. Test E was a variety-defoliation test on two commercial varieties, undefoliated as compared to defoliated at four different dates from time of tagging blooms.

The combination of research facilities at Stoneville are such that it has been possible to gather data not only on actual cotton production, but also on the operation of new and improved cleaning, drying, and ginning equipment, and the ultimate effect of all the various station tests on cotton fiber strength, grade, and fineness, and quality of seed. This has been possible only through the cooperation of the U. S. Cotton Ginning Laboratory, Cotton and Fiber Testing Laboratory, and the Cottonseed Analysis Laboratory. By sending samples to the spinning laboratories at Clemson, S. C., and College Station, Tex., results in terms of spinning quality have also been obtained. The entire research program is drawn up in close cooperation with Delta farmers who advise with the personnel at the station through the advisory research committee of the Delta council. This same committee does much to carry back to the farmers of the Delta what the station is developing in the way of mechanized farm operation.

One of the first things to consider in farm mechanization is field layout. Fields to be mechanized must have good drainage, since wet and low spots will retard machine operations. Turn rows must be wider for tractor operation than where mules have been the source of power. It is recommended that a 20-ft alley be left for turning of four-row equipment. It has been the experience of the Delta station that seedbed preparation is especially important in mechanized farming. Successful mechanical operations depend on uniformity of seedbed. In the fall of the year, after cotton stalks are cut, the row is broken with a three-row, tractor-mounted "middle buster". This three-row machine does a much more satisfactory job of putting up beds of even height than a two-row machine. Even if the middle plow has to be raised and only two bottoms operated because of lack of tractor power, a more uniform bed can be thrown up than with two-row equipment. It is almost impossible, in the case of mule operation, to space beds properly while a tractor using markers will do an excellent job. In the spring one operation rebreaks these beds and places fertilizer, putting it below the seed drill. This practice does

[6]Gerdes, Francis L. Mechanization of Cotton Production in the Mississippi Delta: Its Relation to Cotton Quality and Marketing Practices. Sixth Cotton Research Congress, Dallas, Tex. In press.




The machine attached to this John Deere tractor is a one-row Finklea cotton chopper

not broadcast the material close to the surface for use of weeds and grass in getting an early start and growth ahead of the cotton plant.

These beds, when dragged down for planting, assure a seedbed free of hardpan. The beds are leveled as flat as possible, leaving only ridge enough to indicate to the tractor operator where to plant. The leveling operation can be accomplished by the use of the disk harrow followed by a spike-toothed harrow, and done as a four-row operation or by large sweeps on the planter. Flat planting and cultivation is very important in subsequent operations. As an example, the flame cultivator does its most efficient job on a flat bed where proper adjustment of burners can be more readily made. When the mechanical harvester is put into the field at the end of the row, it is more nearly in picking position where flat cultivation has been practiced. In fields having conditions other than this, it may be necessary to handpick the ends of rows in order to make a proper entrance into the row and avoid missing cotton. Another advantage of flat cultivation is the matter of putting into a wet field any machine, such as the ground unit for distributing defoliant, that might cause ruts in the middles and cancel out the benefits to the picker of flat cultivation.

The cotton planting operation is done with a four-row, tractor-mounted planter. From the standpoint of complete mechanization, the most critical time in weed and grass control during the growing season of cotton is that period from emergence of the seedling plant until it is large enough to be flamed. During this interim, from two to three weeks depending on the season, grass in the drill with the cotton plant continues to grow even though cultivation destroys weeds and grass in the middles.

During the cultivation season it has been the practice at the Delta station to cultivate and flame at least once a week, weather permitting. Last year the crop received eleven cultivations and eight flamings. The crop was free of any grass or weeds at lay-by time and was thoroughly clean when harvesting began during the latter part of September.

#### DEFOLIATION IS TO MECHANICAL HARVEST OF COTTON WHAT FERTILIZATION IS TO PRODUCTION

Defoliation is as much a part of the mechanical harvest of cotton as fertilization is of production. The use of ground machines to distribute defoliant is less economical than airplane, but still remains necessary to many farm operations. However, in cotton of rank growth, it is practically impossible, even when fenders are used, to run a ground machine without seriously damaging both the fruit and the plant.

Cotton has been harvested for a number of years by such methods as sledding, snapping, and stripping. These methods are more common in the plains areas of Texas than in the Delta since they have not yet proved practical for Delta growths. In the Delta, the cotton plant, after frost, tends to rot rather than become brittle and the bur does not separate easily from the branch, as in arid sections. In recent years the International Harvester Co. has developed an economical cotton picking machine. Much additional work will have to be done to enhance its efficiency and adaptability to other than flat terrain and typical Delta operations. Lack of availability of machines is the major problem in the Delta today.

The use of water as an aid in the picking and doffing of cotton in the mechanical picker has created problems in ginning and handling. During the latter part of 1944, a wetting agent was added which reduced needed water volume by 50 per cent. Two of these commercial wetting agents were used in 1945 and drying, ginning, fiber, and seed analysis tests showed no harmful effects. This test was indicative of a need for some material that could replace water altogether. This problem of entirely eliminating water in the picking process may well be solved by the use of Texspray, a mineral oil heretofore used in gins of arid sections where static electricity is a problem, and in mill operating rooms to reduce fly and dust. Second picking tests, after the cotton plant was dead, showed that one pint of oil per bale is sufficient for picking and keeps the spindles cleaner than does water. Texspray has been used to facilitate ginning. Its use in picking should reduce storage problems to those equal to handpicked cotton.

Harvesting and insect control problems in cotton both pose questions of cotton variety. One particular "smooth leaf" variety has been selected by Dr. E. W. Dunnam, and S. L. Calhoun, U. S. Bureau of Entomology and Plant Quarantine, cooperating with the Delta station for insect control work. This particular cotton has also been found to be more readily cleaned after harvesting by mechanical methods than any other variety. It is believed that the fewer the hairs on a cotton leaf (pilosity), the more readily can that lint cotton be cleaned during the ginning process.

Contemplated studies for 1946 and following years will continue to compare plantation versus mechanization studies and will repeat the quality studies involving variety, exposure, and methods of picking. Also, the lint and seed-cotton cleaning studies will be continued in cooperation with the U. S. Cotton Ginning Laboratory. A facet of this program will be the breeding for plant characters that will aid in picking and cleaning of lint and seed cotton.

Defoliation studies need to be expanded. Physiological and biochemical studies are urgently needed since there is much we do not know about the when and how of defoliation. The expanded program should include a large number of varieties and greater variation in age of plants.

#### EXPANSION OF FLAME CULTIVATION IS NEEDED MORE THAN ANOTHER PART OF THE RESEARCH PROGRAM

The one field of flame cultivation alone, probably more than any part of the research program, is in great need of expansion. More extensive work is proposed in testing and developing types of machines, fuels, burners, and combinations of seedbed preparation, tillage, and flame cultivation. There are many questions and problems to which flame may be the answer. For instance, it is known that the lower branches of a cotton plant are in the main vegetative rather than productive. It may be that by destroying these lower branches with flame, cultivation will be facilitated. The cotton plant is highly adaptable, and it may be assumed that any fruit these lower branches might bear will be put on higher up in the plant.

As stated previously, the control of weeds and grasses until time of regular flame cultivating remains the paramount gap in the mechanized program today. It is hoped that, by flaming the seedbed prior to time of planting and again after the top soil has been disturbed, growth of weeds may be destroyed. It is possible also, that a third flaming after the planting operation and just before the young cotton seedling comes through the surface might aid in control. The flame cultivation of crops other than cotton, such as corn and soybeans, presents problems in row-crop and broadcast flaming and inject the element of speed of operation. Flame may be the answer to problems of fallow; eradication of noxious weeds and grasses in alfalfa; elimination of weeds and vines on ditch banks, fence rows, and turn alleys. A device has been developed that enables the application of insecticides and fumicides simultaneously with cultivation and flaming. *(Continued on page 422)*

# Preliminary Engineering Studies for Dam Design

By Samuel R. Sapirie

ENGINEERING studies are expensive. The salary and expenses for a typical survey party are approximately $100 per day. Similar costs for a drilling crew total approximately $125 per day. Hydraulic model studies normally cost from $1,000 to $20,000 each, depending upon the scope and completeness of the tests. Other types of engineering investigation required for dam design are similarly expensive. These high costs are responsible for the tendency that has developed, in the past, to limit the engineering investigations severely, thereby very often requiring that the design be based upon insufficient studies.

The lack of adequate engineering studies, however, is generally much more costly than are the studies themselves. Plans based upon inadequate engineering studies usually result in structural failures, unbalanced design, or overdesign. Fig. 1 shows a spillway that failed shortly after completion of construction, under flood conditions considerably less acute than the type of storm it was designed to meet. The deficiencies of this spillway could have been disclosed, prior to construction, in a hydraulic model study, and corrected for little, if any, additional cost. Because this was not done, the entire investment is lost and a new spillway must be built. In Fig. 2 is another spillway that failed shortly after completion of construction, under flow conditions considerably less than had been contemplated. The left abutment is sliding into the spillway, moving the sidewalls and buckling the floor slab. A proper investigation of the foundation soil conditions would have disclosed a thick layer of very expansive material underlying the spillway site. This made the site extremely undesirable. The spillway could have been moved several hundred feet to the right, or a reanalysis of all data might have indicated that the project should have been abandoned. The spillway shown in Fig. 3 illustrates what is meant by unbalanced design. The flow at the time the photograph was taken was approximately 20 per cent of the design capacity of the spillway, but this flow already exceeds the safe capacity of the spillway channel. The spillway crest has adequate capacity for the design flood, but this capacity cannot be discharged safely through the spillway channel. A hydraulic model study would have disclosed this condition. Another example of unbalanced design is illustrated in Fig 4. The floor slab at the lower end of the spillway failed and the subsequent undercutting removed the sidewalls. It is interesting to note that the sidewall sections were moved intact and after having been tossed around by the turbulent waters were found to be free of cracks or breaks. The floor slab and the inadequate drainage system under the floor slab were responsible for the failure and once they failed, the sidewalls, although properly designed, also failed. Inadequate spillway discharge capacity and insufficient freeboard might cause failure of the dam even though the spillway was otherwise adequate in every respect. Proper hydrologic and flood routing studies usually will prevent this type of failure.

Where adequate basic data are not available, safe design requires very conservative assumptions and costly overdesign. The more dependable the data, the smaller the margin of overdesign needs to be. Consequently, if by making additional engineering studies the cost of construction can be reduced by more than the cost of the additional studies, it is desirable to do so.

This raises the question of how much study should be made.

Where life or valuable property are endangered, thorough study should be made to insure safety under all possible conditions.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Birmingham, Ala., February, 1946.

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Fig. 1 *(Upper left)* Spillway failure due to poor hydraulic operation. Deficiencies could have been disclosed prior to construction, in a hydraulic model study • Fig. 2 *(Upper right)* Spillway failure attributed to movement of abutment and foundation soils. Core boring and soils test would have disclosed presence of layer of highly expansive material underlying spillway site • Fig 3 *(Lower left)* Unbalanced design illustrated as capacity of spillway channel is exceeded although discharge is less than 20 per cent of the design flood for which the spillway crest was designed. Hydraulic model study would have disclosed this condition • Fig 4 *(Lower right)* Spillway failure caused by uplift pressure under slab near point where hydraulic jump occurred. Subsequent undercutting removed sidewall sections, which, after having been tossed around by the turbulent waters, were found to be free of breaks or cracks.

For the smallest type structures, where economic factors dictate a design that will partially fail under certain conditions, the study should be limited to the minimum that will permit balanced design for approximately the life required. General studies can be made that are applicable to a large number of small structures. For example, hydraulic model studies are being made in the hydraulic laboratory at St. Anthony Falls, Minn., and other laboratories for stilling basins for small structures which can be used under a wide range of conditions. Similarly, soils studies have been made in western Iowa to develop design criteria for embankments for a large number of small dams that are being constructed with essentially the same type of soil foundation conditions.

The greatest problem is that of determining the optimum amount of studies to be made in connection with the intermediate size structures. The size of structure is not necessarily a criterion of the amount of study required. For the intermediate size structures, the answer must be based on engineering judgment of the amount of funds that can be saved in construction costs due to balanced design and reduction in overdesign that would result from additional studies as compared to the cost of those studies.

The engineering studies required for the intermediate size dam will now be described briefly, assuming that the site, type and size of structure required have been decided, and also assuming that special studies to determine water yield and potential reservoir silting have been completed satisfactorily. A certain amount of engineering studies must be completed before this assumed status is reached, but such assumptions free the discussion of the many ramifications connected with justification, economic considerations, and special type structures.

The preliminary engineering studies for intermediate size dams must include several types of field surveys. A survey must be made to determine the size, shape, slope, cover and erosion, and soil infiltration factors of the drainage area. Aerial photographs, U. S. Geological Survey maps, and all other existing maps and data should be carefully checked in the field to determine their accuracy, and used if applicable. Thus the field survey can be limited to securing the minimum of information that cannot be secured from other sources. Complete surveys must be made of the reservoir area unless accurate detail surveys have already been made and are available. Normally the reservoir area survey should have an accurate triangulation control with the detail provided by either plane table or stadia surveys. Usually a 5-ft contour interval and a linear scale of 1 in = 500 ft will suffice for the reservoir area map. These scales will be varied, however, depending upon the size and relief of the reservoir area. The dam site map should be based upon an accurate detail topographic survey using a grid system and providing ample area to include all possible appurtenances to the structure. A dam site map normally should have a 2-ft contour interval and a linear scale of approximately 1 in = 50 ft. An additional survey is required in the valley below the dam site for use in determining the tailwater curve or the water surface elevation at the downstream toe of the dam for various rates of spillway discharge. This survey should cover the valley from one-half to two miles downstream, dependent upon the location of controlling stream cross sections. It should provide valley profile data with indication of reaches of similar hydraulic characteristics and typical cross sections for each reach. High water data and roughness coefficients at various stages should also be indicated. A series of photographs showing typical channels with various roughness coefficients is included in Appendix A. 7 of the handbook, "Low Dams". (National Resources Committee publication, U. S. Government Printing Office).

Foundation and borrow pit exploration and investigation form the second major type of studies. The purpose of these studies is (a) to determine if there is any rock available to which the structure can be anchored or the cutoffs sealed, (b) to determine the possibility of seepage under or around the structure and the permeability of the foundation and borrow pit soils, and (3) to determine the stability of the foundation and borrow pit materials.

The advice of a competent engineering geologist is desirable and is considered necessary for important structures.

The specific information desired is (a) the depth and type of overburden on the rock under the site of the proposed structure, (b) the location and extent of zones or faults in the foundation through which seepage and piping could occur, (c) the shape and location of the rock surface if it is within a reasonable depth for possible use, (d) the type and condition of the existing rock; (If limestone is present, is it soft or hard, porous or tight, and is there any evidence of solution channels? If sandstone is present, is it fractured or massive, fine or coarse, well or poorly cemented? If shale is present, is it compaction or cementation type; does it slake when exposed to water; is it solid or disintegrated?) ; (e) type and condition of soils in foundation and borrow pits (this includes classification, coefficient of permeability, optimum moisture content, consolidation and stability) ; (f) degree of solubility of soils and rock; and (g) availability of natural materials for construction purposes: riprap, sand, gravel and soil (this information will affect cost of construction, thereby influencing the type of design).

Samples of both soil and rock should be secured for visual and laboratory inspection and analysis. There are several methods of sampling, but in general soil samples should be taken by a dry sampling method. Test pits are desirable for samples from shallow layers, but due to the high cost this method is not practicable for deep holes. For the deeper holes, auger or core drill holes are desirable for securing samples. Undisturbed samples must be secured and protected for use in shear and compression tests. The protection of these samples requires complete coating with paraffin to prevent loss of moisture or disturbance. Samples should be retained for every change of material, or at least once every 5 ft for uniform material. Labels and field logs should be prepared containing the following information: date, location, boring number, sample number for that boring, surface elevation, depth at which sample was taken, representative of stratum from — ft to — ft, and field classification. Special notations should also be made of the elevation at which ground water or any special condition was encountered.

Rock samples should be secured by core drilling, using a diamond drill, calyx drill or other special types, depending upon the hardness and type of rock encountered. The cores should be retained in entirety, with reference being made to hole number and depth. Wooden boxes can be used to transport and store the cores.

The location and depth of holes required is dependent upon the type material encountered and the size and type of structure being planned. A general plan should be established before drilling is started, in order to insure proper coverage. A small number of deep core holes can usually be supplemented with a large number of auger, general-purpose holes to develop profiles. The plan should be made flexible enough to permit changes during drilling operations, based upon results of the first or succeeding holes. As an example, the first holes might be spaced 100 ft apart. These holes might disclose that the existing material is uniform except for a limited area. In this area, it would then be desirable to drill additional holes on 50-ft, 25-ft, or smaller spacing.

The procedure and technique for laboratory soil tests have been developed and generally standardized during the last 10 years. Publication No. 268 of the graduate school of engineering of Harvard University (January, 1940), entitled "Notes on Soil Testing for Engineering Purposes," by A. Casagrande and R. E. Fadum, summarizes the laboratory procedure generally followed at the present time. Classification tests are made of the soils materials to determine general characteristics and to permit the grouping of samples by soil types. These tests include grain-size analysis by a combined sieve and hydrometer method to determine grain-size distribution, Atterberg limits (which disclose the liquid and plastic limit and plasticity index of the material), water content, and specific gravity. The shear strength of the foundation and borrow pit soils is determined by triaxial compression tests and direct shear tests. Permeability tests are made to determine the amount of seepage through the foundation and through the proposed embankment. Consolidation tests are made to determine the amount of settlement that will occur in both the foundation and in the embankment when the embankment is constructed. Compaction tests are made to determine the optimum water content and the maximum dry and wet densities at which the borrow pit material can be consolidated in the embankment. The results of these tests provide data with which to design embankment cross section and drainage system and to determine the factor of safety, the amount of leakage that will occur, the location of the phreatic line, the amount of settlement that can be expected and the procedure to be followed in construction of the embankment.

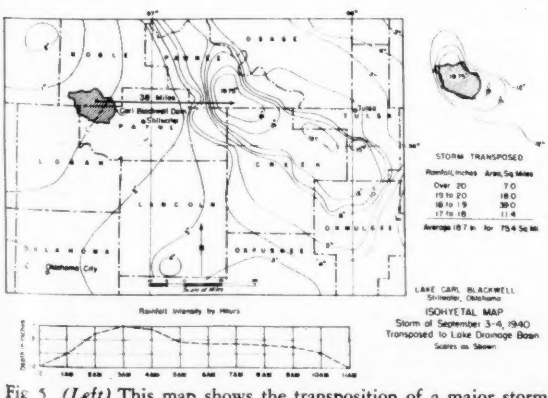
Hydrologic studies are required to determine the size of the flood for which the spillway must be designed. The first part of the hydrologic study is the collection of basic data. Data can be secured from the U. S. Weather Bureau, the War Department, the U. S. Geological Survey, and the Soil Conservation Service, in addition to other special sources. It is important that the data be reliable. Information provided by local residents, based upon casual observation, is sometimes unreliable. All such information must be carefully weighed. The War Department has been collecting pertinent data regarding major storms in all sections of the country. We have found this information to be very valuable in facilitating the completion of hydrologic studies.

The most satisfactory methods available for developing the design storm for very small drainage areas are based upon empirical curves and formulas, or the Rational method. There are numerous such empirical curves and formulas that are applicable to the various sections of the country, but one must be familiar with their use or the results can be very misleading. The Rational method is based upon the equation $Q = CIA$, where $Q$ is the peak discharge in cubic feet per second, $C$ is the ratio of maximum peak flow per acre given in cubic feet per second to the average rate of rainfall in inches per hour throughout the period of concentration, $I$ is the average rainfall intensity in inches per hour prevailing during the time of concentration, and $A$ is the drainage area in acres. This method also requires careful use since various assumptions of the $C$ and $I$ values and the time of concentration can bring widely different answers.

These methods are objectionable for larger structures because either efficiency or safety is usually sacrificed. For the intermediate size structures the unit-hydrograph method as developed for larger drainage areas is believed to be most practicable. This method is explained in Chapter 5, Article 22 of Volume I, "Engineering for Dams," by Creager, Justin and Hinds (John Wiley and Sons, 1945). The unit-hydrograph method is based upon the assumption that for any given drainage area the graph of runoff from a rainfall of some unit of duration will have ordinates in direct proportion to the number of inches of runoff-producing rainfall. The unit hydrograph represents 1 in of runoff from the drainage area, for a rainfall of a certain unit of duration. This could be 3, 6, 12, or any number of hours. Smaller drainage areas require smaller units. For intermediate size drainage areas, a 6-hr unit hydrograph is usually satisfactory. A storm of longer duration can be broken into several unit durations and the excess rainfall applied against the unit hydrograph to develop an outflow hydrograph for each duration. The summation of the ordinates for the several periods provides an outflow hydrograph for the entire storm. The unit-hydrograph method therefore permits the consolidation of major storm precipitation data and runoff data from different areas with similar rainfall-producing and runoff characteristics for application to the specific drainage area.

The use of the unit-hydrograph method is handicapped by the limitation of basic data. Rainfall and runoff records now available are for relatively short periods of time and records are not available for many of the small streams.

The use of precipitation data for major storms in all areas of like rainfall-producing characteristics can be utilized by direct transposition, or by the use of depth-area curves. Fig. 5 shows how the storm of September 3-4, 1940, in central Oklahoma, was transposed 38 miles west and applied to the drainage area above a dam under consideration, in an effort to anticipate the most severe rainfall for the drainage area. The average rainfall over the drainage area, if the storm had been centered as transposed, would have been 18.7 in for the total drainage area of 75.4 sq mi. Fig. 6 shows the maximum depth-area curves for the



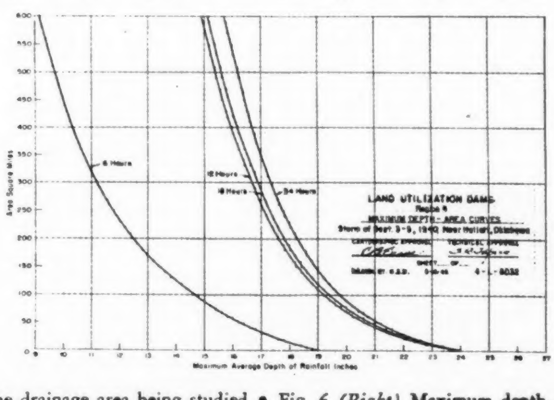




Fig. 5 *(Left)* This map shows the transposition of a major storm to the drainage area being studied • Fig. 6 *(Right)* Maximum depth-area curves for the same storm as shown in Fig. 5

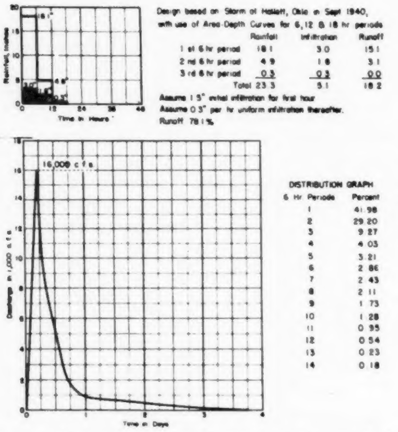



Fig. 7 A design flood developed with the use of the depth-area curves, infiltration rates for prevailing soil type, cover and slope, and synthetic unit hydrograph

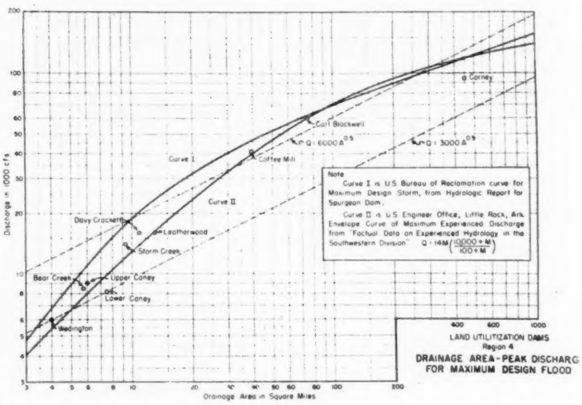



Fig. 8 Peak discharges for design floods developed for dams now under consideration, plotted according to size of drainage areas and compared to U. S. Bureau of Reclamation and U. S. War Department curves

same storm. These curves indicate the maximum average depth of rainfall, in inches, for a 6-hr period of the storm, a 12-hr period, an 18-hr period, and a 54-hr period, for any area from 0 to 600 sq mi. The use of these curves yields a larger average rainfall than by direct transposition of the storm, but, as an added factor of safety is usually desirable, and as the curves simplify the use of the storm data, this method is generally used. The maximum average depth of rainfall for the 75.4 sq mi in the drainage area mentioned above would be 20.0 in if the maximum depth-area curves were used instead of the 18.7 in secured by direct transposition.

Gaging stations and discharge data are usually not available at the sites for intermediate size dams. It is therefore usually necessary to secure the unit hydrograph by adapting runoff data from a larger or smaller size drainage area on the same stream or another stream of like runoff characteristics, or by developing a synthetic unit hydrograph. The lag, in hours, for similar drainage areas of different sizes varies in direct proportion as the square root of the size of the drainage areas in square miles. Similarly, the peak discharge for the two drainage areas will vary as the square root of the size of the drainage areas.

The Snyder method of developing synthetic unit hydrographs, as described in the article, entitled "Synthetic Unit Graphs," by Franklin F. Snyder, in Part I of the 1938 Transactions of the American Geophysical Union, has been found to give results that closely approximate the recorded unit graphs for the areas that we have considered.

In addition to the data on major storms and the unit hydrographs, it is necessary to know the minimum rate of infiltration that would result from a major storm in the drainage area. There are two critical rates to be considered, namely, the initial infiltration and the uniform infiltration that follows after the initial infiltration limit has been reached. The infiltration data can be secured either by field determination or from use of research station data. The USDA Technical Bulletin 729 (July, 1940), "Relative Infiltration and Related Physical Characteristics of Certain Soils," provides basic data for most of the soil types we have considered. Slope and cover and erosion data are used in the final determination of infiltration rates.

The minimum infiltration rate data is applied to the maximum rainfall data so as to determine the most severe runoff conditions for use in developing a conservative design flood. Fig. 7 illustrates a design flood developed with use of the depth-area curves for the Hallett, Okla., storm of September, 1940, a synthetic unit hydrograph developed by the Snyder method, and infiltration rates secured from USDA Technical Bulletin No. 729, with the assistance of soils technicians familiar with the area. Fig. 8 summarizes the peak discharge for the maximum design flood, as developed by this method for a number of dams under consideration, plotted with relation to size of drainage area in square miles and compared to curves of the U. S. Bureau of Reclamation and the U. S. Engineer Corps Office at Little Rock, Ark.

The peak of the design flood is reduced by the effect of the reservoir storage capacity above the spillway crest elevation in determining the discharge peak for the spillway. The amount of reduction is, of course, dependent upon the relative size of the reservoir storage capacity. To determine the amount of reduction, it is necessary to have a curve showing the reservoir storage capacity at various elevations above the spillway crest elevation and also to have an approximate rating curve showing the discharge for the spillway under consideration. There are two methods generally used to route the flood through the reservoir and spillway, either of which is satisfactory. The "trial-and-error" method is mathematical. Assumptions are made of the water surface elevation, by increments of time, the reservoir storage capacity of which will absorb the difference between the flow into and out of the reservoir. Each assumption is checked and the process continued. The "graphical" method uses the same general principle, but is somewhat simpler and is more readily checked to determine the accuracy of the final results. Fig. 9 summarizes the results of flood routing by the graphical method for a relatively large reservoir, in which case the maximum discharge is reduced from the 60,000 cfs peak of the inflow hydrograph to the 15,700 cfs peak of the spillway outflow hydrograph. Fig. 10 summarizes the results of graphical flood routing for a reservoir that has a very unfavorable storage relationship, in which case the spillway discharge peak of 56,200 cfs is almost as great as the inflow hydrograph peak of 56,400 cfs.

There are several possible relationships of spillway crest length to discharge head that can be used for any given dam location. The spillway crest elevation is usually fixed by other factors, e.g., storage capacity required, etc., but the additional head required for a crest of shorter length can be made available by increasing the height of the dam. It is desirable, therefore, to prepare rating curves for several different spillway crest lengths for use in flood routing of the design storm. The use of a shorter length crest

will result in a saving in cost of construction of the spillway, but will require an additional cost of construction of the embankment. The most efficient design will, of course, result from the length of crest which provides the lowest total cost for construction of the spillway plus the embankment.

The computations must provide for a freeboard above the maximum water stage. The amount of freeboard is determined with use of Stevenson's formula for wave action, in which the height of wave from trough to crest, in feet, $= 0.17 \times \sqrt[2]{VF} + 2.5 - \sqrt[4]{F}$, in which $V$ is the wind velocity in miles per hour and $F$ is the fetch or straight length, in nautical miles, of water subject to wind action. A factor must be applied to the height of wave to provide for the ride-up on the sloping side of the embankment and a further addition must be made to provide for frost action in the earth embankment. These factors will vary in different locations, and we have found that for the dams now under consideration by the Soil Conservation Service in the western Gulf Region the freeboard provided by applying a factor of 1.4 to the total height of wave secured from the Stevenson formula provides a satisfactory figure.

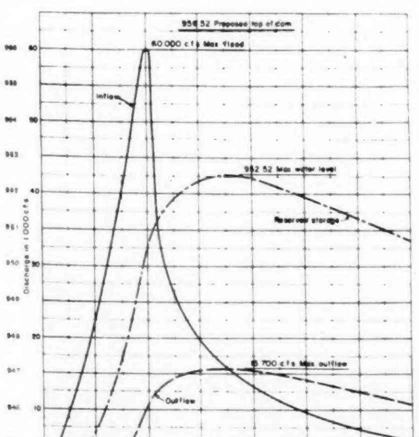
An additional study must be made to develop tailwater curves to show the range in depth of water in the outlet channel at the dam site that should be expected for various rates of discharge. All or part of the tailwater curves can sometimes be secured from stream-gaging records. The records, however, normally do not contain sufficient data to provide for the upper end of the curve for discharges approaching and exceeding the design storm. Nevertheless gaging station records, where available, are valuable in determining the roughness coefficient for guidance in estimating the roughness factor to be used for greater rates of discharge. If sufficient stream gaging records are not available to permit the development of a complete tailwater curve, it is necessary to compute such a curve. Two principal methods are generally used. The first is the "long-distance bed-slope method," in which Kutter's $n$ (roughness coefficient) is estimated for various depths of flow at the dam site, and the long distance bed slope and average hydraulic characteristics for typical sections are used to determine the discharge at the dam site for various depths of flow. This method can be simplified somewhat by drawing three curves showing the relation between depth of flow in each case against (1) average areas, (2) average wetted perimeters, and (3) $n$ values. The second method is known as the "backwater curve" method. A control point is established one or two miles downstream and then, using estimated values of $n$ and average hydraulic characteristics for each reach, the water-surface elevation is computed upstream to the dam site for various discharge rates. The advantage of this method is that considerable latitude is permitted in estimating the water stage at the control point. Any normal error in the original estimate is practically eliminated by the time the calculation has been carried through several reaches up to the dam site. This method can also be used for graphical determination of the tailwater curve, as explained in King's "Handbook of Hydraulics," under the description of Leach's backwater method. We have found the graphical method preferable.

The tailwater curve must, of course, reflect the effect of any water being discharged through the emergency spillway and all stream branches into the valley immediately below the dam. Fig. 11 illustrates the tailwater curves developed for a structure under consideration by the Soil Conservation Service, in which flood conditions on the main creek below the dam site have an effect upon the depth of water in the stream channel at the dam site. This therefore makes possible a wide range of tailwater depth, particularly for the lower discharge rates.

Upon completion of the aforementioned studies, one is ready to prepare preliminary designs of spillways. Such preliminary designs, in so far as practicable, should be based upon accepted design practice. Unorthodox designs should be avoided. Open channel or overfall-type spillways are preferable to side channel, syphon, or other special types, although special conditions sometimes dictate the use of a special design.

With use of a standard ogee-shaped weir crest, it is usually possible to increase the efficiency of the entrance about 25 per cent over an open channel spillway without such a crest, and thereby reduce the width of the spillway at the entrance proportionately. The overflow crest section shown in Chapter 9:5 of the handbook, "Low Dams," may be used for preliminary design. In order to have maximum crest efficiency, it is necessary to have the approach channel deep enough to avoid high-velocity flow. For very low heads the approach depth should be equal to 0.6 times the head, but a depth of approximately 3 ft is adequate for heads up to 8 ft. The approach channel should be free of obstructions and shaped so as to encourage symmetrical flow.

Stilling basin design has been given considerable study in hydraulic laboratories and has resulted in general acceptance of certain principles. Such basins make use of the



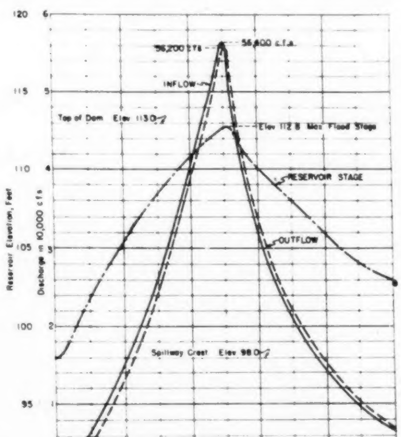




Fig. 9 *(Left)* This hydrograph shows the results of routing design flood through a relatively large reservoir in which case the peak discharge rate is only 15,700 cfs, as compared to the peak inflow rate of 60,000 cfs. Reservoir capacity has a major effect on the discharge rate • Fig. 10 *(Right)* This hydrograph shows the results of routing design flood through a relatively small reservoir. The peak discharge rate of 56,200 cfs is almost as great as the peak inflow rate of 56,400 cfs. The reservoir has a negligible effect on discharge rate

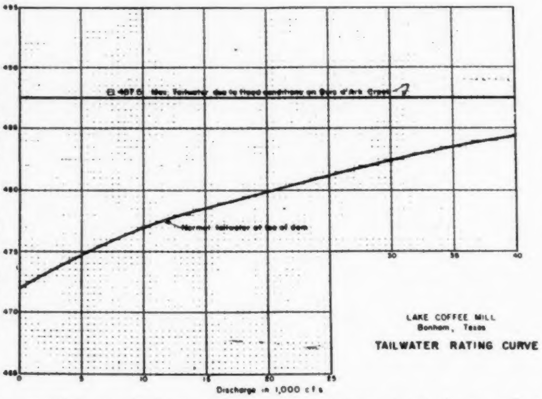



Fig. 11 This graph shows the range in tailwater depth due to effect of main creek below the dam site on the depth of water in the stream channel at the dam site

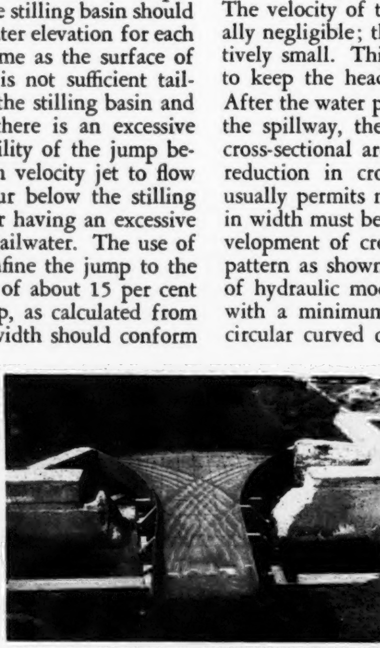
hydraulic jump for dissipating energy and reducing velocity. The conditions that are required for the hydraulic jump can be solved with use of the "momentum" formula, provided the depth of water and velocity at the entrance to the stilling basin are known for various rates of discharge. The momentum formula is as follows:

$$d_2 = \frac{d_1}{2} + \sqrt{\frac{d_1}{4} + \frac{2v_1 d_1^2}{g}}$$

where $v_1$ is the velocity above the jump, $d_1$ is the depth above the jump, $v_2$ is the velocity below the jump, and $d_2$ is the depth below the jump. Various curves have been developed for the graphic solution of the above equation. The set of curves shown as Fig. 44 of the "Low Dams" handbook was developed by the U. S. Bureau of Reclamation and permits simple solution of the equation. With knowledge of the depth of water below the jump, it is possible to use various empirical relations to complete the design of the stilling basin. The length of the U. S. Bureau of Reclamation basin should be approximately three times the depth below jump. The floor elevation of the stilling basin should be established so that the normal tailwater elevation for each discharge rate is approximately the same as the surface of the water below the jump. If there is not sufficient tailwater, the jump will occur outside of the stilling basin and will cause considerable scour. If there is an excessive amount of tailwater, there is a possibility of the jump being drowned out, which causes a high velocity jet to flow along the floor tending to create scour below the stilling basin. More latitude is permissible for having an excessive tailwater than having a deficiency in tailwater. The use of floor blocks and an end sill helps confine the jump to the stilling basin and permits a reduction of about 15 per cent in the depth of water below the jump, as calculated from the momentum equation. The basin width should conform to the outlet channel in so far as practicable, but it may be adjusted to permit the location of the stilling basin floor at a satisfactory elevation. The height of the stilling basin sidewalls should provide adequate freeboard for the depth of water below the jump and for the maximum tailwater depth. The stilling basin floor should be designed with adequate anchorage, weight and drainage to counteract the uplift pressure caused by the difference in depth of water over a comparatively short length of floor slab. Practicable design usually does not permit the use of a sufficient thickness of concrete to provide the weight necessary to offset the entire difference of pressure for the maximum flow condition. In such instances, the design usually provides for sufficient thickness to withstand the normal difference in tailwater and depends upon drainage relief to protect the floor slab under maximum discharge conditions.

The channel between the crest and the stilling basin should, if practicable, be symmetrical about the center line and should have a straight alignment for high-velocity flow. It is satisfactory to use curved approach channels above the spillway and curved discharge channels below the spillway where the velocities are subcritical, but in the spillway channels where above-critical velocities exist, it is desirable that the channels have straight alignment. Critical velocity is the velocity at which a given quantity of water flows with minimum energy head. Under such condition the water is said to be flowing at critical depth. Critical depth equals two-thirds of the total specific energy, the remaining one-third being velocity head. In other words, the velocity head is equal to one-half the depth of water. The use of curves in the alignment of the spillway channel causes the high velocity water to pile up on the outside of the curves and develops standing waves. It is difficult to determine the wave height and hence the wall height required. The use of spillway channel curves makes it difficult to secure uniform distribution of flow into the stilling basin. Such flow is necessary for efficient operation of the stilling basin.

In open channel spillways it is usually possible to effect a saving in construction cost by using a channel width less than the length of spillway crest. This is due to the basic hydraulic equation—discharge equals area times velocity. The velocity of the water approaching the spillway is usually negligible; therefore, the velocity over the crest is relatively small. This requires a long length of crest in order to keep the head over the crest within reasonable limits. After the water passes the crest and continues flowing down the spillway, the velocity is usually increased so that the cross-sectional area can be reduced. The utilization of the reduction in cross-sectional area by reducing the width usually permits maximum saving; however, such reduction in width must be made carefully in order to prevent the development of cross waves in the familiar diamond-shaped pattern as shown in Fig. 12. We have learned by the use of hydraulic model studies that by using curved sidewalls with a minimum radius of approximately 1,000 ft and a circular curved crest normal to the point of beginning of



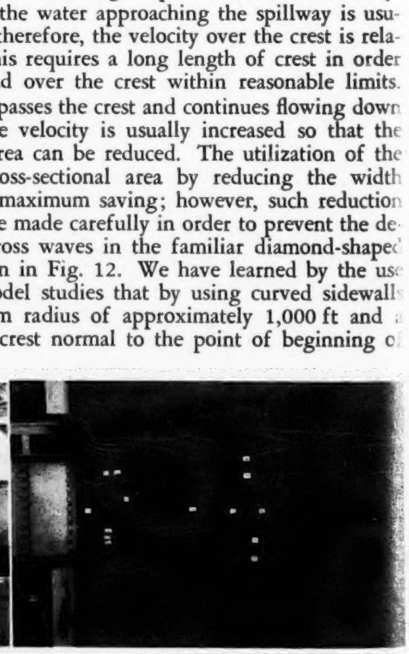


Fig. 12 *(Left)* This hydraulic model demonstrates the development of cross waves in a diamond-shaped pattern due to rapid reduction in channel width • Fig. 13 *(Right)* This view shows the scour pattern resulting from model run illustrated in Fig. 12

curve of the sidewalls, it is possible to effect reduction in channel width without creating harmful waves. In such designs, however, it is desirable to use a relatively flat gradient for the floor slope for the portion of the spillway where the sidewalls are curved and a relatively steep grade for the lower end of spillway into the stilling basin. The gradient of the floor at the upper end should be sufficient to maintain a velocity slightly in excess of critical velocity. A slope of 3 horizontal to 1 vertical for the lower or chute section of the spillway has been found to be satisfactory.

Where the grade changes from relatively flat to steep, it is desirable to have a long radius curve to prevent the development of excessive negative pressures. A vertical curve with a radius of approximately 100 ft is usually satisfactory for the grade change indicated above. In the preliminary design of the channel the water-surface flow line and energy grade line should be computed for maximum discharge rate. The height of the sidewalls required is determined by adding the necessary freeboard to the maximum water-surface elevation. The flow line and energy grade line are computed with use of Manning's formula by the usual progressive trial-and-error computation, starting at the lake surface elevation for the maximum design flood. Fig. 14 is a preliminary design for one of the spillways now under consideration by the Soil Conservation Service.

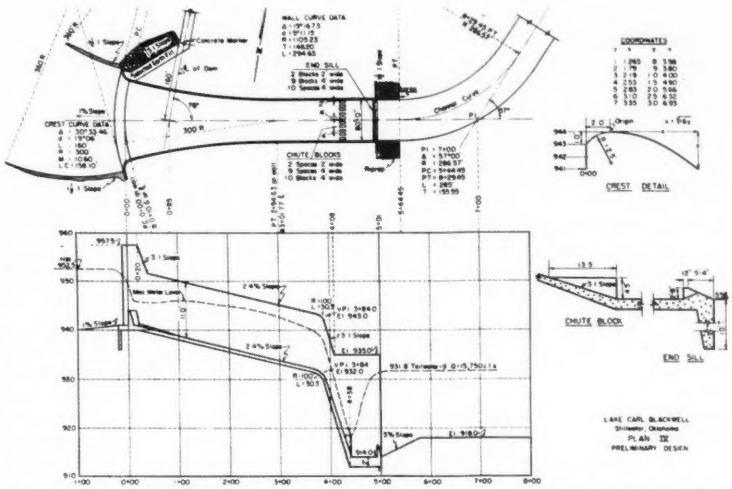



Fig. 14 The preliminary design of a new spillway resulting from engineering studies.

It is sometimes possible to consider several preliminary designs which appear to be equally satisfactory for all of the existing conditions affecting design. The choice between such preliminary designs is determined by the relative cost of construction. Cost studies are therefore made to determine the most efficient design. Where cost estimates must be prepared for a large number of spillways for these economic studies, we have found it desirable to prepare curves showing the cost per lineal foot for various wall heights and unit costs for floor slab, drainage and excavation items. These data do not provide an exact answer regarding the cost of constructing a single structure, but do indicate the relative costs of the several structures.

Upon completion of the cost studies, it is usually desirable to conduct hydraulic model studies to check and refine the best preliminary design to insure economy and safety. Such model studies are based upon the laws of hydraulic similitude. A definite scale ratio such as 50:1 is used and the results of the model are multiplied by the proper ratio to obtain the prototype condition. In spillways the slopes are usually relatively steep so that the gravity forces are dominant and other forces such as friction are relatively unimportant. Under these conditions the following relationships apply: (a) length for prototype equals the length of the model times the linear ratio; (b) time for the prototype equals the time for the model times the square root of the linear ratio; (c) velocity for the prototype equals the velocity for the model times the square root of the linear ratio; (d) areas for the prototype equal areas for the model times the square of the linear ratio, and (e) discharge for the prototype equals discharge for the model times the 5/2 power of the linear ratio. The hydraulic models satisfactorily reproduce the flow pattern and velocity distribution and amount. Fig. 15 shows a comparison of the model and prototype for the same spillway at approximately the same rate of discharge. The scour patterns below the models show the relative efficiency of the stilling basins, but do not necessarily reflect the precise depth of scour for the prototype. Fig. 13 shows the scour pattern after the completion of the model run shown in Fig. 12. It is desirable to have the model studies made at an established hydraulic laboratory and with use of skilled personnel because experienced judgment must be exercised in conducting and interpreting the tests.

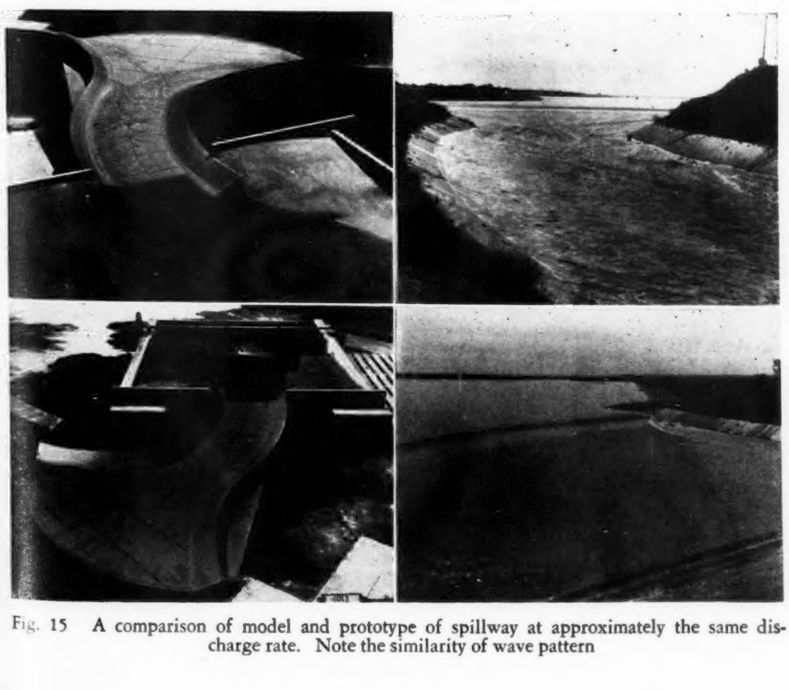


Fig. 15 A comparison of model and prototype of spillway at approximately the same discharge rate. Note the similarity of wave pattern

It is necessary to provide the hydraulic laboratory with complete basic data in order to insure satisfactory results. The basic data should include the following: (a) topographic map of the spillway site with approach and outlet areas shown in detail, (b) plans showing dimensions and elevations of preliminary spillway designs to be considered, (c) spillway rating curves showing the stage-discharge relationship up to design flood peak plus 50 per cent, and (d) tailwater rating curves showing the water depth in stream below the spillway for all spillway discharge quantities up to the design flood peak plus 50 per cent. Close liaison should be maintained between the hydraulic laboratory and the design office.

The principles and practice of hydraulic model studies as generally adhered to at the present time are summarized in the American Society of Civil Engineers' Manuals of Engineering Practice, No. 25, entitled "Hydraulic Models."

The hydraulic laboratory is usually equipped with a water storage tank and pump with capacity adequate for the ratio of prototype to model being used. A scale ratio of about 50:1 has been found to be desirable for model studies of the spillway that we are now investigating. Small size structures can be studied on larger scale models. The rate of discharge of water is determined with the use of either a Venturimeter or a calibrated weir. The velocity of flow is measured with either pitot tube or current meters. The direction of flow is determined with chips of confetti, dye, or simple flow direction indicators. The scour pattern is measured with use of a sounding rod on scaled guides which are movable on measured rails. Model of the spillway is usually constructed of wood to accurate measurements at an undistorted scale ratio. The entrance conditions are simulated by molding sand or plaster to the correct shape.

### DESIGN OF MODEL SHOULD PERMIT MODIFICATION WITHOUT COMPLETE RECONSTRUCTION

The model should be designed so as to permit modifications during tests, without complete reconstruction. The normal method of operation is to mold the sand bed below the spillway to the proper shape to simulate the stream bed. The model channel is then flooded to bring the tailwater to the correct elevation. Flow is then started through the spillway and the discharge rate and tailwater depth are then adjusted. The depth of flow and velocities are measured at various points. Photographs are taken during and after tests to show characteristic conditions. Tests are run for several representative discharge rates, usually up to the design flood plus 50 per cent. Tests are also run with the tailwater depth varying from the tailwater curve so as to determine the tailwater range for which the model will operate satisfactorily. The results of the tests are compiled with complete notes of all information of particular interest. The scour pattern is measured and the extent of erosion and deposition resulting from each run are indicated by plotting contours. The model is modified at the laboratory to correct any hydraulic deficiencies or to reduce the cost of construction. Such modifications are confined within limits imposed by the design office. After completing modifications of the model, additional tests are made to determine their effect. Sketches should be prepared showing recommended changes in the preliminary design and a complete report prepared, summarizing the results of the model study. General conclusions can sometimes be reached that are applicable to several similar spillways so that individual detail tests need not be run.

As a result of the model studies, it is usually desirable to modify the preliminary design and cost estimate to reflect the improvements found desirable. The results of all tests and studies should then be considered in a critical review of the final preliminary design. In case any doubt exis regarding the adaptability of the design to the local topo graphic conditions, a survey should be made and the stru ture staked out at the site and all questionable conditio checked.

The preliminary studies should be summarized in a r port showing the basic data and assumptions used and t results of all tests leading up to the established design. T preliminary engineering studies can then be considered co plete and the structural design initiated.

## Flame Cultivation and Other Mechanization of Cotton

(Continued from page 414)

More work is needed on this. Tests should also be set up study the effect of flaming alone as compared to flaming t drill and cultivating the middles for the last two or thr cultivations before the crop is laid by. It may be that the last cultivations of middles cut the feed roots of crops a seriously affect yields. A test should also be conducted handling the entire crop by flaming with no mechanical c tivation by plows.

Studies are needed on the use of picking aids in t early season, and on the variations in the aggressiveness picker spindles which Texspray would seem to allow. T study would show the related effect of doffing efficiency aggressiveness of spindles and would include the effect the agent and these operations on cleaning of seed cott and lint, as well as cleanliness and efficiency of operati of the machine itself. The Texspray studies would inclu picker efficiency, also evaluate the quantity of cotton pick as related to value.

The scope of the research program at Stoneville is su that all cotton interests have displayed much interest in Facilities for coordinated research, plus the adaptability the region to mechanized operation, lend themselves to t solution of many of the fundamentals of efficient producti and processing of quality cotton. Some of the engineeri aspects of southern agriculture have been long neglect There is a great deal of information needed on tilla stress and strain on machines as related to soil types, a similar information. Then, too, it is known that if south agriculture is to progress for the material and human be fit of southern people, research must lead the way and agricultural engineer has a definite part to play in south agriculture.

## Family Farm Opportunity

(Continued from page 397)

War-born shortage of labor has emphasized the need a opportunity for increasing work efficiency by mechanizati work simplification, high-yield crops and livestock, other production engineering and good farming princip

It appears that small, closely knit, going concerns, w labor, management, and capital all represented in a sm group of individuals working together in mutual inter have a great opportunity to set an example and lead the to full production. They are ideally adapted to balance t applications of labor, management, and capital so that e may contribute its maximum to their combined producti The result can only be increased total output and maxim earnings creditable to each factor in production.

The family farm is one large class of enterprise of type in an unusually favorable position to show what ca done by the balanced application of labor, management, capital toward a common production objective.

# A Soil Sampler for Pore Volume Studies

By Russell Woodburn and T. N. Jones
MEMBER A.S.A.E. MEMBER A.S.A.E.

MANY types and sizes of soil samplers have been introduced in the field of soil science for various purposes. Several existing samplers were tried in connection with the soil pore space studies in Mississippi and none were found exactly to fit the needs of the work. In this study it was necessary to have comparatively large samples (300 cu cm or more) in order to reduce laboratory errors in measurement.

In any study of pore volume it is necessary that the soil sample be as free as possible of compression or disturbance by sampler action. On some field sites non-capillary pore volume was as low as 1 or 2 per cent and would have been entirely eliminated by a small amount of sampler compression.

After preliminary studies of various sampler designs it was decided that a sampler for pore volume studies should meet the following specifications: (1) A thick sample must be avoided—probably not in excess of 2 in should be taken in one container; (2) the sampler must have as thin a wall as available material will permit, thereby minimizing soil disturbances; (3) the sampler must permit driving into the ground, rather than jacking, in order that samples may be obtained in any location and at any time of the year; (4) the soil must be tight enough in the sampling tube to permit moving sample, as taken, to laboratory for processing.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is approved as technical paper No. 120, new series, by the Director, Mississippi Agricultural Experiment Station, and by the Division of Research, Soil Conservation Service, U. S. Department of Agriculture.

RUSSELL WOODBURN is associate agricultural engineer, Soil Conservation Service, USDA, and T. N. JONES is head, department of agricultural engineering, Mississippi Agricultural Experiment Station.

It is the purpose of this paper to present a description of the sampler that was designed and some results of performance tests.

*Construction of the Sampler.* The soil sample is taken in a 2-in section of seamless steel tubing, 3½ in ontside diameter, with a wall thickness of 0.049 in. This tubing was not thick enough to resist the crushing pressure of a lathe chuck when held for cutting into sections and machining. It was found necessary to design a jig for holding the material while the machine work was done.

The jig is shown in Figs. 1 and 2. The tubing is slipped over the open end of the jig and cut into sections slightly over 2 in long. These sections are then placed on the jig and cut to exact length–2 in–and both ends are squared. The lower end of the 2-in section is then chamfered to the desired sharpness for driving. Since the end of the jig is a guide for the final cutoff, all sections are identical in length.

When conditions are such that full stocks of seamless tubing are available, it is recommended that a thinner wall than 0.049 in be used, probably as thin as 0.033 in. A jig of some type would then be even more necessary for machine operations on the material.

*Use of the Sampler.* The sampler tube or cylinder is forced into the soil by means of a round steel head bearing

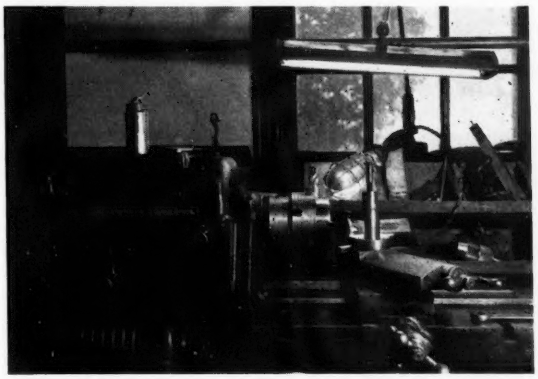


Fig. 1 This picture shows the jig (used in making steel soil sampling cylinders) in place on lathe with a sampling cylinder being sharpened

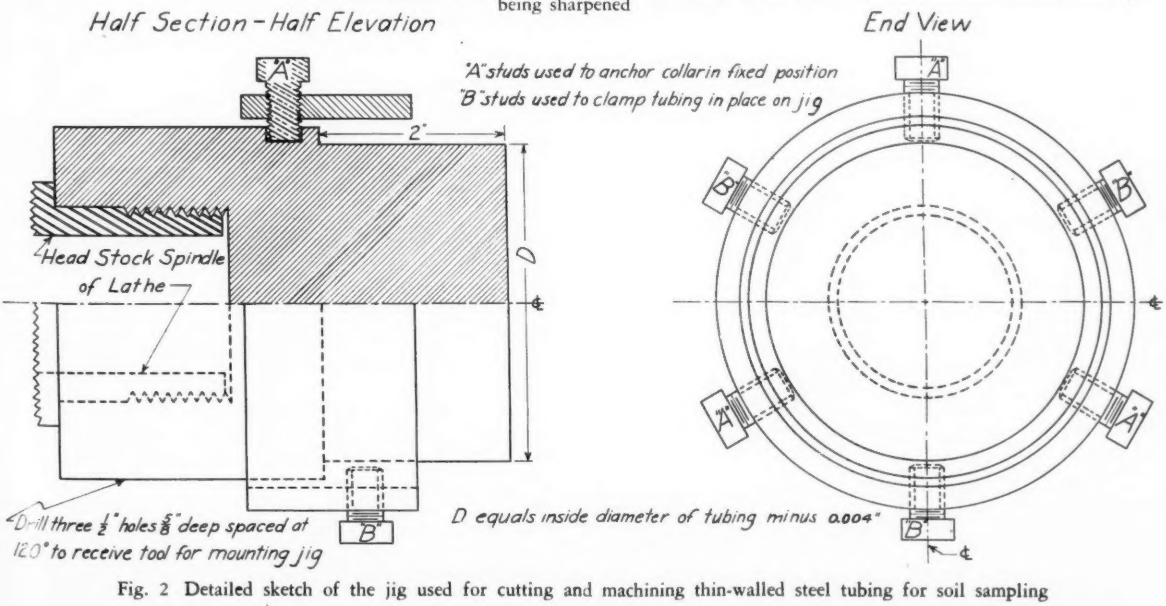



Fig. 2 Detailed sketch of the jig used for cutting and machining thin-walled steel tubing for soil sampling

Fig. 3 *(Left)* This shows the driving head, two soil sampler sections, and a machinist's hammer • Fig. 4 *(Right)* The soil sampler in operation. Samples are usually taken in duplicate

uniformly on its top end. The ball end of a 3-lb machinist's hammer is used to drive upon the center extension of the driving head. It was found that very light blows of the hammer on the driving head were superior to heavy blows in reducing the amount of compaction. Little difficulty was encountered in driving the sampler into most soils. It is essential that the sampling cylinder be lubricated both inside and outside before forcing into the soil. Warm petroleum jelly has proven satisfactory for this purpose. The driving head, hammer, and two sampler sections are shown in Fig. 3, and the assembly in use is shown in Fig. 4. After a 2-in depth has been sampled, the soil is cut away and leveled in preparation for the next 2-in sample.

*Tests of the Sampler.* The sampler did not cause any apparent compression on most sites when tried in the field. However, detailed data on this point were desired on several representative soil types thought to present unusual difficulties. Yazoo clay, Memphis silt, and Houston clay were selected for this purpose. These mineral soils are practically structureless materials of very high porosity (see Table 1). These materials of high porosity (due to lack of grading) were considered to present a greater problem in sampling than a well-graded soil. Another soil type, Tabor, was selected because it contains a hardpan a few inches below the soil surface.

A round steel block slightly smaller than the sampling cylinder was equipped with a large steel ball welded to its top and used for an elevation reference. This steel block was placed upon the soil surface and a level rod reading on top of the ball was taken to nearest 0.001 ft before cylinder was driven. After driving, the steel block was again placed

Table 1. DESCRIPTION Of SOILS And RESULTS Of DRIVING TESTS

| Soil type | Texture characteristics | Volume weight | Moisture, content, % dry weight | Compression, ft |
|---|---|---|---|---|
| Yazoo clay | | | | |
| 2-10 in | 80% clay | 1.05 to 1.13 | 50 | 0 |
| Memphis silt | | | | |
| 8-9 ft | 90% silt | 1.18 to 1.28 | 15 | 0 |
| Tabor sandy loam | | | | |
| 0-2 in | Well graded to high sand | 1.59 | 12 | 0 |
| 2-5 in | Well graded | 1.81 | 18 | 0 |
| 5-10 in | Well graded to moderate clay | 1.57 to 1.67 | 20 | 0 |
| Houston clay | | | | |
| 2-10 in | 60% clay | | | |
| One group of 3 cylinders | | 1.28 to 1.33 | 34 | 0.004* |
| One group of 5 cylinders | | 1.20 to 1.33 | 36 | 0 |

*Only soil type on which compression was found. This very sticky clay appears to be sensitive to areas of minor roughness on inside of walls.

on the soil surface and another reading obtained. Difference in rod readings was a measure of the amount of compression, if any, in the soil core. Performance was satisfactory on Yazoo, Memphis, and Tabor. Some difficulty was experienced with Houston clay. Compression of 0.003 ft to 0.005 ft was observed in some samples (Table 1).

It was thought that compression of a sample was a direct function of surface drag on the inside wall of the cylinder. It was, therefore, considered necessary to keep the cylinders as smooth as possible. The ordinary steel tubing used in these sections had a pronounced tendency to rust and pit. It was found very helpful to polish the tube sections in a lathe with 2/0 emery and a dry powder, such as Bon Ami, after each use. Stainless steel, when available, is recommended for future use.

After the sample is obtained in the field, the soil core must be smoothed off even with both top and bottom of the sampler tube. Some difficulty has been encountered in this operation on heavy clay samples. There is a tendency to smear or seal the soil pores, and the closed pores interfere with suction table tests. A hand hack saw blade with the set ground off the teeth is the most satisfactory tool found to date for this cutoff work, although it leaves much to be desired.

Preliminary tests indicate that the seal may be broken by placing the soil core momentarily on a red hot steel plate. A very thin film is instantly brought to dryness and the cracking and checking in this film gives access to the undisturbed soil above. The second or two interval on the hot plate is not long enough to appreciably reduce the moisture content above this film.

## CONCLUSION

On the basis of several month's experience and field tests the sampler appears to be satisfactory for the design purpose.

Samples of undisturbed soil may be taken which will permit precise determination of porosity for most soil types. Within the limits of existing suction table technique, size distribution of the pores may then be made.

The jig design used is somewhat expensive in first cost but will permit an unlimited number of sampling cylinders to be made easily of identical length and trueness.

The sampler may generally be used to advantage on soils offering difficulties, such as hardpans and other impervious sites. If a soil should be encountered where appreciable compression occurs, special precautions should be taken. The actual amount of compression may be determined by elevations on the soil surface before and after driving and volume correction should be made.

# Drying Ear Corn in Farm Cribs by Natural Ventilation

By Claude K. Shedd
FELLOW A.S.A.E.

ANY proposal to dry corn artificially must be based on the thesis that the customary practice of drying by storage in farm cribs is not entirely satisfactory. Artificial drying, if it is to be economically feasible, must either reduce the cost per bushel or else produce corn of better quality than would be obtained by crib storage. Consideration of the results obtained by customary methods of ear corn storage is essential in establishing the value of artificial drying.

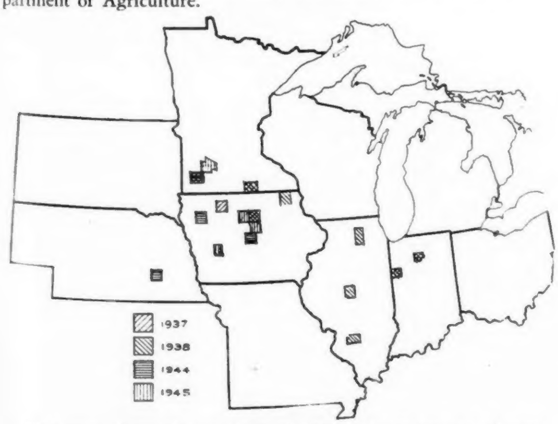
The grain storage research work of the U. S. Department of Agriculture included numerous observations of storage of ear corn in farm cribs during the years from 1937 to 1945. These studies were carried on in certain counties in Indiana, Illinois, Iowa, Minnesota, and Nebraska. (See accompanying map). From each crib under observation, probe samples were obtained for moisture and damage determinations in the winter and again late in the spring or in the summer. These data showed how much the corn had dried and how much damage had developed under different conditions.

Prior to 1944 the crops were mature and in normal condition at harvest time. A large part of the corn in these storage studies prior to 1944 was sealed under Commodity Credit Corporation loans under a requirement that the moisture content must be not more than 20.5 per cent. The 1944 and 1945 crops were generally high in moisture content in the northern part of the Corn Belt. A large part of the corn in storage studies these last two years contained from 20 to 30 per cent moisture when first sampled. The 1944 crop was generally mature but high in moisture content throughout the Corn Belt. The 1945 crop was immature in extensive areas at the end of the growing season.

The effect of the moisture content at the first inspection upon the grade of corn produced by crib storage in the crop years 1937, 1938, 1940, 1941, 1944 and 1945, is shown in Table 1.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946, as a contribution of the Farm Structures Division.

CLAUDE K. SHEDD is agricultural engineer, division of farm buildings and rural housing (BPISAE), U. S. Department of Agriculture.




This map shows the locations of USDA investigations of corn storage in farm cribs

In storage of the 1937 crop, 194 cribs were observed which contained corn with less than 20.1 per cent moisture. Only 32.5 per cent of these cribs produced No. 1 corn; 26.8 per cent produced No. 2 corn; and, at the other extreme, 12.4 per cent produced sample grade. With higher moisture contents, the percentage of cribs producing sample-grade corn increased. (Grade factors other than damage were not considered in these analyses.)

Conditions apparently were more favorable for storage of the 1938 crop. All of the 110 cribs observed contained corn with less than 20.1 per cent moisture. No. 1 corn was produced in 51.9 per cent of these cribs and no crib produced corn worse than No. 3.

Of the cribs containing corn of the 1940 and 1941 crops with less than 20.1 per cent moisture, No. 1 and No. 2 corn was produced in 23.6 per cent of the cribs in 1940 and in 70.5 per cent of the cribs in 1941.

Good results were obtained in storage of the 1944 crop. All of the 24 cribs with corn under 20.1 per cent moisture produced No. 1 corn. Where moisture was above 30 per cent, only No. 5 and sample grades were produced.

In 1945-46 there was a combination of high moisture and immaturity of the corn and unfavorable weather conditions for drying during the storage period. This resulted in a large amount of badly damaged corn in cribs in northern Iowa and Minnesota. Of the 15 cribs observed containing corn with less than 20.1 per cent moisture, only one crib produced No. 1 corn. Where the moisture content was above 23 per cent, nothing better than No. 5 corn was produced.

TABLE 1. EFFECT OF MOISTURE CONTENT ON GRADES OF CORN PRODUCED BY CRIB STORAGE (Based on Damage Only)

| Storage year | No. of cribs | Corn moisture at first inspection, per cent | Grades of corn produced, per cent of cribs | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | Sample |
| 1937-38 | 194 | under 20.1 | 32.5 | 26.8 | 12.9 | 8.2 | 7.2 | 12.4 |
| | 23 | 20.1 - 23.0 | 13.0 | 8.7 | 4.3 | 13.0 | 26.0 | 34.8 |
| | 4 | 23.1 - 26.0 | 25.0 | | | | | 75.0 |
| 1938-39 | 110 | under 20.1 | 51.9 | 45.5 | 2.7 | | | |
| 1940-41 | 17 | under 20.1 | 11.8 | 11.8 | 29.4 | 41.2 | 5.9 | |
| | 2 | 20.1 - 23.0 | | | 50.0 | | | 50.0 |
| 1941-42 | 17 | under 20.1 | 23.5 | 47.0 | 5.9 | 5.9 | 11.8 | 5.9 |
| | 3 | 20.1 - 23.0 | 33.3 | | 33.3 | | | 33.3 |
| 1944-45 | 24 | under 20.1 | 100.0 | | | | | |
| | 27 | 20.1 - 23.0 | 81.5 | 7.4 | 7.4 | 3.7 | | |
| | 11 | 23.1 - 26.0 | 54.6 | 18.2 | 9.1 | 9.1 | 9.1 | |
| | 4 | 26.1 - 30.0 | 50.0 | 25.0 | 25.0 | | | |
| | 2 | 30.1 - 35.0 | | | | | 50.0 | 50.0 |
| 1945-46 | 15 | under 20.1 | 6.7 | 33.3 | 26.7 | 20.0 | 13.3 | |
| | 28 | 20.1 - 23.0 | | 10.7 | 7.1 | 17.8 | 39.3 | 25.0 |
| | 19 | 23.1 - 26.0 | | | | | 10.5 | 89.5 |
| | 13 | 26.1 - 30.0 | | | | | | 100.0 |
| | 3 | 30.1 - 35.0 | | | | | | 100.0 |

Taking corn of the same original moisture content, a large variation is found in the results obtained in different years. Apparently this variation in results is due to weather conditions although no good correlation is found between storage results and monthly averages of weather conditions (see Table 2). It is only under favorable weather conditions that a moisture limit of 20.5 per cent will insure production of corn grading No. 1 or No. 2 by customary methods of crib storage. Cribbing corn with 23 to 26 per cent moisture is risky and moisture content above 26 per cent is likely to result in severe damage. These conclusions apply specifically to an area north of the centers of Indiana, Illinois and Iowa, where most of the observations were made. *(Continued on page 427)*

# Forced Drying of a Farm Crib with Heated Air

By Thayer Cleaver
MEMBER A.S.A.E.

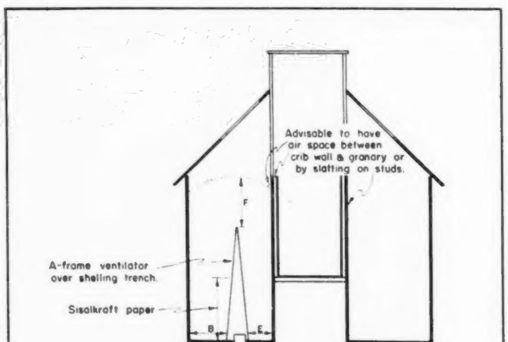
THE test described in this paper was made between February 20 and March 19, 1946, in a farmer's corn crib near Lena, Illinois, and is a cooperative project of the agricultural engineering department, University of Illinois, and the division of farm buildings and rural housing, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture. The primary reason for this test was to find out if a typical farm crib, preferably a large one, could be dried successfully and economically with a comparatively inexpensive heating unit. Other information of value from this test included (1) uniformity of heat and air distribution, (2) proper balance between heat supplied and volume and velocity of air supplied, (3) drying rate, and (4) method of drying.

The ear corn crib selected for this test was a large concrete-stave double crib, with semicircular outer wall, overhead bins and 1x4-in cribbing along the driveway. Only the west half of the crib was used. The farm owner had already installed a new forwardly curved blade, centrifugal-type, double-inlet fan capable of delivering 10,000 cfm in the crib with the proper pulleys on the motor and fan. The fan was driven by a 3-hp electric motor and was actually delivering only about 6,000 cfm against a pressure of 0.35 in of water.

When this crib was filled with 1945 corn the grain contained 32 per cent moisture and the cobs 47 per cent, wet basis. At the time of filling the farmer estimated on a volume basis a total of 2,500 bu in the crib. This would be approximately 2,050 bu on a basis of 15 per cent moisture in the grain. It was very difficult to get a true average moisture sample from the crib because a corn probe could not be inserted in the concrete-stave openings. Samples were taken along the driveway from the floor upward to the overhead bins and from the surface of the corn downward about 2 ft. At the end of the test a small metal hook was made with which samples were taken next to the outer wall.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946, as a contribution of the Farm Structures Division.

THAYER CLEAVER is agricultural engineer, division of farm buildings and rural housing (BPISAE), U. S. Department of Agriculture.




A sketch of the corn crib tested, including recommendations for preparing it for forced ventilation

The heating unit consisted of three weed burners, two of which were used all the time, and the third was used when one of the first two was being refueled or cleaned. The burners were placed with the heating units in the open end of a horizontal empty oil drum. Fire brick were placed in the far end of the drum so the bottom would not burn out. The purpose of the drum was to help stop any sparks that might form from the burning of the fuel and to mix the heated air more uniformly before being drawn into the fan inlet. The drum also prevented any possibility of flames coming into contact with inflammable material. A canopy was fitted around the drum and fan so that all air drawn into the fan was drawn over and around the heated drum. The canopy consisted of sections of plywood and transite with about 3¾-in air space between.

Each of the four periods of heating was continuous and an operator was required to be present at all times to keep up the pressure on the fuel tanks, make observations and take data. The following data summarize results of the test:

1 Approximately 2,050 bu in the crib immediately before test began (based on 15 per cent moisture in the grain, wet basis).

2 Moisture contents immediately before start: 27 per cent in grain, 35 per cent in cobs, wet basis.

3 Amount of water to be removed in reducing moisture content of kernels from 27 to 15 per cent was 9.4 tons from the kernels and approximately 13.8 tons from both kernels and cobs.

4 A total of 95 hr unheated air was forced through the crib before the heating test began and removed about 5 per cent moisture. This 95 hr total plus 77 hr more of unheated air ventilation between heating periods made a total of 172 hr of unheated air ventilation.

5 In addition heat was applied for 212 hr. Total time of heated and unheated air during test, 289 hr. Of the 77 hr of unheated air during the test, only 27 hr were very useful because they followed immediately after heating periods. This not only cooled the grain down to prevent spoilage before the next heating period, but it also removed additional moisture while cooling to the outside temperature.

6 Temperature in fan duct during first 136 hr of heated air varied from 85 to 95 F. During the last 76 hr of heated air a second large burner was installed and the fan duct temperature averaged 130 F.

7 During the first 136 hr most of the heated air went to the end of the plenum chamber farthest from the fan and especially into the upper half. As the corn dried it settled, and the distance from the top of the A-frame to the corn surface became the path of least resistance for the air. Consequently, it was necessary to block the upper fourth of the plenum chamber farthest from fan with boards and place canvasses on the surface of the corn to force air through

the wettest portions.

8 Air delivery was 13.0 cfm per sq ft of plenum chamber wall.

9 Electric energy consumed by fan motor since installation was 505 kw-hr. Total consumed from time heating period started until end of test was 375 kw-hr. Power cost was 2c per kw-hr. This amounted to 0.37c a bushel for power cost. Total of 583 gal of kerosene used for heating cost 10c a gallon. This averaged 2.84c a bushel. Total fuel and power costs were 3.21c a bushel to remove 12 per cent moisture from 2,050 bu.

10 Moisture content of grain samples taken at the end of the test ranged from 8 to 21 per cent. The areas most difficult to dry were next to the overhead bins and the extreme ends of the driveway because air could not be forced through these areas satisfactorily.

If the knowledge gained from the test could have been available at the start, a considerable saving in time and fuel could have been made and drying would have been much more uniform throughout the crib. It is concluded that (1) 450 gal of fuel should have been ample; (2) 164 hr of heat application should have been ample; (3) drying should have been continuous; (4) the upper fourth of the plenum chamber farthest from the fan should have been restricted to not more than 50 per cent of what it actually got and the lower fourth farthest from the fan to not more than 75 per cent at the start (the final test is to check the velocity of the escaping air around the crib walls and on the surface and adjust the blocking in the plenum chamber accordingly); (5) the depth of corn from the top of the A-frame to the surface should have been 2 ft more than the distance to the walls to allow for settling (the accompanying sketch illustrates the crib tested and recommendations for preparing it for forced ventilation), and (6) heat should be discontinued in a crib of this size from 4 to 7 hr before the end of the drying period because additional drying will continue until the grain has cooled down to the outside air temperature.

Some commercial organizations during the past winter charged 16c a bushel to dry ear corn from about 35 per cent down to 12 to 15 per cent moisture and the farmers had to haul the corn to and from the drier. If the cost of the new burner which was purchased and used for the last 76 hr of the test is added to the fuel and power costs, the total would be only 6.45c a bushel.

The method of drying by means of introducing air into the shelling trench, rather than into an A-frame plenum chamber, seemed satisfactory if properly blocked, but a better plenum chamber would have the outer side curved to conform with the curved crib wall. This would give a more uniform air distribution but would be more difficult to construct.

# Drying Ear Corn in Farm Cribs by Natural Ventilation

*(Continued from page 425)*

There is less difficulty in crib storage of corn in the southern part of the Corn Belt because corn is more certain to mature fully and to be dry enough for safe crib storage when harvested.

There are other important factors in crib storage such as width of crib, clean preparation of corn, and use of ventilators. Time will permit only a brief statement regarding these factors. As to crib width, indications are that present recommendations are not far from correct.

| Month | Avg. temp., deg F | Precipitation, in | Avg. wind velocity, mph | Avg. rel. humidity 6:30 p.m., % | Sunshine, % |
|---|---|---|---|---|---|
| | | | 1937-38 | | |
| Oct. | 50.3 | 2.03 | 7.9 | 57 | 55 |
| Normal | 51.4 | 2.37 | 8.3 | 60 | 59 |
| Nov. | 33.9 | 0.72 | 9.7 | 59 | 61 |
| Normal | 36.2 | 1.59 | 8.9 | 68 | 50 |
| Dec. | 22.8 | 0.74 | 9.1 | 73 | 39 |
| Normal | 24.0 | 1.19 | 8.7 | 74 | 45 |
| Jan. | 21.0 | 1.14 | 9.5 | 72 | 45 |
| Normal | 18.5 | 1.10 | 8.9 | 75 | 51 |
| Feb. | 29.0 | 0.94 | 9.4 | 75 | 35 |
| Normal | 22.3 | 1.09 | 9.2 | 73 | 56 |
| Mar. | 43.7 | 2.35 | 10.1 | 59 | 54 |
| Normal | 34.5 | 1.73 | 9.7 | 62 | 58 |
| Apr. | 50.3 | 3.65 | 11.0 | 51 | 60 |
| Normal | 48.7 | 2.73 | 9.9 | 55 | 58 |
| | | | 1938-39 | | |
| Oct. | 59.4 | 0.88 | 8.2 | 52 | 76 |
| Nov. | 37.6 | 2.76 | 9.6 | 62 | 59 |
| Dec. | 26.3 | 0.71 | 8.9 | 68 | 48 |
| Jan. | 28.7 | 0.86 | 8.9 | 75 | 49 |
| Feb. | 20.3 | 1.75 | 10.7 | 65 | 62 |
| Mar. | 36.4 | 1.79 | 9.5 | 62 | 69 |
| Apr. | 47.8 | 2.07 | 10.4 | 50 | 60 |
| | | | 1944-45 | | |
| Oct. | 53.8 | 1.08 | 7.4 | 60 | 73 |
| Nov. | 40.4 | 1.73 | 9.6 | 78 | 23 |
| Dec. | 20.6 | 1.29 | 9.1 | 79 | 43 |
| Jan. | 19.3 | 0.67 | 8.0 | 82 | 42 |
| Feb. | 25.5 | 1.43 | 8.9 | 76 | 42 |
| Mar. | 45.3 | 2.88 | 10.1 | 60 | 66 |
| Apr. | 48.7 | 4.38 | 12.0 | 58 | 56 |
| | | | 1945-46 | | |
| Oct. | 51.8 | 0.33 | 8.3 | 50 | 67 |
| Nov. | 36.9 | 1.25 | 10.4 | 71 | 47 |
| Dec. | 18.0 | 2.02 | 9.5 | 80 | 41 |
| Jan. | 22.8 | 1.82 | 10.2 | 78 | 57 |
| Feb. | 28.8 | 0.36 | 10.8 | 65 | 59 |
| Mar. | 47.0 | 4.18 | 9.8 | 67 | 54 |

Cleanness of preparation has been studied in experimental cribs at Ames, Iowa. Samples taken May 2, 1946, showed 32.0 per cent damaged kernels in a crib filled in October, 1945, with corn as it came from a mechanical picker with about 26 per cent moisture in the grain. Only 5.6 per cent damage was found in an identical crib filled with the same kind of corn except that it was rehusked clean by hand. It has been shown in these experiments that clean preparation makes a marked improvement in the results obtained by crib storage of high-moisture corn.

A good many cribs provided with various kinds of ventilators were observed in 1944-45 and 1945-46. Specifically, the percentages of cribs which were equipped with some kind of ventilator were as follows: 1937, none; 1938, none; 1944, 18 per cent; 1945, 44 per cent. Vertical flue-type ventilators were of questionable value. Horizontal open-wall tubes imbedded in the corn with the ends of the tubes exposed to wind pressure caused a definite reduction in damaged corn in the immediate vicinity of the tubes, particularly in the area just above the tubes. A-frame ventilators were effective in reducing damage up to the level of the top of the ventilator but not more than 1 to 2 ft above this level. A ventilator 6 in wide, with horizontal passageways for air under wind pressure, placed in the center of the crib so as to divide the crib into two narrow cribs, appeared to be equally as good as the A-frame ventilator. Observations on the performance of ventilators are not sufficient to set any definite figure as to their value. A guess would be that a good ventilator may take care of an extra 3 to 5 per cent moisture in the corn. That is, if 20 per cent moisture is the safe limit for storage in a crib without ventilator, the limit with a good ventilator in the same crib might be from 23 to 25 per cent moisture.

Results of these investigations show that customary practices in crib storage of corn can be materially improved by clean preparation and by use of the best types of ventilators. But the best practices in crib storage are likely to produce sample grade corn if the initial grain moisture content is as high as 25 to 30 per cent.

# A-E Instruction for Vo-Ag Teachers

ON May 3 to 5, 1946, a joint meeting of representatives of the American Society of Agricultural Engineers and of supervisory and teacher training staffs of vocational agriculture in the eleven western states was held in Santa Fe, New Mexico. This meeting was the second in a series of regional meetings sponsored jointly by the A.S.A.E. and the U. S. Office of Education to apply and to implement in the Pacific region the recommendations made in the report of the A.S.A.E. Committee on Agricultural Teacher Training, entitled "Agricultural Engineering Phases of Teacher Training for Vocational Agriculture," issued in June, 1944.

Arrangements for this meeting were made by J. D. Long, then president of A.S.A.E., and E. J. Johnson, federal agent, agricultural education, U. S. Office of Education. Some thirty individuals representing each of the eleven western states and the Territory of Hawaii were in attendance and participated in the meeting.

Consideration was given to the following problems and items:

1 The nature of the instructional needs in farm mechanics for the Pacific region.

2 The instructional needs of prospective teachers and teachers of vocational agriculture in the region.

3 The organization of a training program in farm mechanics and suggestions as to content of courses.

4 The hours and units of credit needed in each course.

5 When training should be given — pre-service and in-service.

6 The training needs of special teachers of farm mechanics.

In the absence of Mr. Long, S. S. Sutherland of California represented the A.S.A.E. and served as co-chairman of the conference with Mr. Johnson of the U. S. Office of Education. The following papers were presented and summaries of each appear in the conference report: "Purpose of the Conference," by Dr. H. B. Swanson, specialist in teacher training, agricultural education, U. S. Office of Education; "The Farm Mechanics Program of Today and for Tomorrow," by A. H. Hollenburg, specialist in farm mechanics, U. S. Office of Education; "Farm Mechanics Instructional Needs of Teachers," by Mark Nichols, state supervisor, agricultural education, Utah; "Organizing the Course of Study in Farm Mechanics," by J. R. Cullison, state supervisor, agricultural education, Arizona, and "The Responsibility of Agricultural Engineering Departments in Training Teachers of Agriculture," by H. B. Walker, professor of agricultural engineering, University of California.

Early in the conference, committees were appointed to study the five major areas of instruction in agricultural engineering, to make recommendations regarding the "must" content to be included in courses for prospective teachers, to estimate the approximate time required for such training, and to list additional in-service training which would be desirable for teachers. Each committee made a preliminary report to the conference and a final report which embodied the suggestions made by the conference group as a whole.

The committee on farm shop work, under the chairmanship of J. R. Cullison of Arizona, recommended nine essential items to be included in pre-service training, and estimated that 125 clock hours of instruction would be necessary to cover them adequately. This is roughly the equivalent of three semester credits. The committee studying farm power and machinery, with Mark Nichols of Utah as chairman, recommended three major areas of instruction in this field as follows: (1) Selecting power units and machines, (2) preventive maintenance, and (3) reconditioning and overhauling. The committee further suggested that wherever possible separate courses be offered in farm power and in farm machinery, but that, if these subjects were combined, they be given in a course carrying at least 4 semester units of credit.

In soil and water management, the committee with Prof. R. W. Canada of Colorado State College as chairman listed eleven major abilities which teachers of agriculture must have, but took cognizance of the fact that some of this instruction may be given in courses in soils, irrigation, and drainage, and similar courses offered by departments other than agricultural engineering. They suggested an average of 108 clock hours of instruction or approximately the equivalent of a 3-unit course, but recognized that there would be considerable variation among states in the emphasis placed on the subject as a whole as well as on the units of instruction within the field.

The rural electrification committee, with Prof. H. A. Winner of the University of Idaho as chairman, recommended four areas of instruction in this field to be included in a 2-semester unit course.

Prof. H. B. Walker of the University of California was chairman of the committee on farm buildings and structures, and this group recommended nine major units as essential for in-service training. In the opinion of the committee, this instruction would require approximately 120 clock hours.

*Summary and Recommendations.* In the final meeting of the conference group, consideration was given to the problem of organizing courses to provide the training recommended by the several committees. In this discussion it was brought out that six of the eleven teacher-training institutions represented operate on a semester basis, and the remaining five on a quarter basis. It was further noted that the trend is toward fewer courses carrying more units of credit.

The following course arrangements were suggested; the examples given are in terms of quarter units, but the general breakdown would also apply to institutions operating on a semester basis:

SUGGESTED COURSE ARRANGEMENTS

| A—Multiple courses | Quarter units | B—Combined Courses | Quarter units |
|---|---|---|---|
| 1 Farm Mechanics (Farm shop work, small buildings and wood projects) | 4 | 1 Farm Mechanics (Two courses: farm shop work, rural electrification, farm buildings and sanitation) | 4+4 |
| 2 Farm Power | 3 | 2 Farm Power | 3 |
| 3 Farm Machinery | 3 | 3 Farm Machinery | 3 |
| 4 Farm Buildings (including rural sanitation and water supply) | 4 | 4 Soil and Water Management | 4 |
| 5 Soil & Water Management (Soil conservation, irrigation, drainage, etc.) | 3 | Total | 18 |
| 6 Rural Electrification | 2 | | |
| Total | 19 | | |

As guides in the further development of this program in the Pacific region, the following recommendations were adopted by the conference group:

1 That provision be made for instructors of agricultural engineering courses, in which prospective teachers of vocational agriculture are enrolled, to observe and maintain contact with farm mechanics instruction in the high schools.

2 That, in spite of the difficulty of scheduling laboratory courses, farm mechanics or farm shop courses should be laboratory courses, and that as much laboratory work as possible be provided in other fields.

3 That, wherever possible, separate laboratory sections be provided for prospective teachers in agricultural engineering courses taught for other agricultural majors.

Copies of the complete conference report may be obtained from J. R. Cullison, state supervisor, agricultural education, Phoenix, Arizona. — Reported by S. S. Sutherland.

## Professional A-E Education

*(Continued from page 406)*

a few, including structural design, are mentioned in the report. A typical basic engineering course of this type which would be included in the "package" recommended for students in farm structures, for example, is fundamentals of architecture. The subcommittee report suggests its postponement to fifth-year graduate study.

It is not intended that basic engineering courses be emphasized at the expense of the very essential so-called fundamental courses like mathematics, english, chemistry, etc. The chosen channel of specialization might contain only elective courses, or space might be provided in the required curriculum suggested in the report by reducing to a very minimum the number and/or length of courses in basic agriculture, social science or agricultural engineering. Introductory courses in the various fields might be combined and taken during the first two years, thus providing space for additional basic engineering work.

*Contact With Industry.* There ought to be closer contact between industry and students in their freshman and sophomore years so that the latter may be advised on choice of specialty and assisted or encouraged by scholarships or other methods. Some summertime work on farms or with industry should be encouraged or required.

*More and Better Graduates.* We need more and better students and graduates. The A.S.A.E. booklet "Agricultural Engineering as a Professional Career" is good. It should be given all possible distribution and use.

The relatively small size of many agricultural engineering departments (both faculty and student bodies) has probably made ag engineering courses seem more informal and less difficult than other engineering courses, and therefore more attractive to poor students. We all need to do a better job of selling our profession. As more students enroll, we will undoubtedly occupy a better position by comparison with other branches of engineering. In this regard every effort should be made to uphold the dignity of the profession by not applying the title "agricultural engineer" to one who does not possess at least a bachelor's degree in agricultural engineering.

The quality of our courses and teachers needs improvement. The subcommittee report referred to will do much to raise the standards. That will help to get more and better students, as will the prospect of many more better-paying jobs awaiting them.

A. R. SCHWANTES

# NEWS SECTION

## North Atlantic Section Program

THE program of the meeting of the North Atlantic Section of the American Society of Agricultural Engineers to be held at Lake Morey Inn, Fairlee, Vermont, September 10 to 12, includes several interesting features. The program for the first day, forenoon and afternoon, will open with an address by Dr. Mark L. Nichols, president of A.S.A.E., and assistant chief (in charge of research), U. S. Soil Conservation Service. T. E. Hienton, head of the USDA Farm Electrification Division, will discuss the research program of his division. A. E. Worth, engineering specialist, New Hampshire and Vermont, will discuss stream bank erosion control. Fires and their causes will be the subject of a paper by Theodore Gunn of the New Hampshire Fire Underwriters' Assn., and "Milk-O-Matic Factory" is the title of a paper by J. E. Van Aernam, of the New York Power & Light Corp. A farm work simplification symposium will include Dr. I. R. Bierly of Cornell University, Dr. R. G. Carter of University of Vermont, and W. C. Krueger of the New Jersey State College of Agriculture as speakers. A business meeting of the Section will complete the program for the forenoon and afternoon sessions. Three round tables—on farm structures, farm electrification, and soil and water conservation—will be held during the evening.

The program for Wednesday, September 11, will include a paper on radiant heat for farm buildings by C. A. Hawk of A. M. Byers Co., another on flood control in the Northeast by James A. Muncey of the U. S. Soil Conservation Service, and another by D. K. Sergeant of Syracuse University on safety in home construction and remodeling. The subject of hay-drying observations will be discussed by G. M. Foulkrod of the University of New Hampshire, J. B. Stere of West Penn Power Co., and O. M. Camburn of the University of Vermont.

The program for Thursday, September 12, will include seven papers as follows: "Flame Cultivation for Northeastern Row Crops," by F. B. Wright, Cornell University; "Homemade Freezer Construction," by G. W. Crowther, University of Connecticut; "Purchasing and Operating Costs of Hay Harvesting equipment," by Dr. Ivan R. Bierly of Cornell University; "New Developments in Farm Buildings," by George W. Johnson of the John B. Pierce Foundation; "Farm Chemurgy and the Agricultural Engineer," by Arnold P. Yerkes of the International Harvester Co.; "Protective Grounding for Farm Structures and Equipment," by A. H. Schirmer of Bell Telephone Laboratories, and "Farmstead Planning," by J. R. Haswell of Pennsylvania State College.

## Washington Section Meeting

THE Washington (D. C.) Section of the American Society of Agricultural Engineers opens its 1946-47 season of monthly luncheon meetings on September 13th, with Dr. O. E. Reed, chief of the USDA Bureau of Dairy Industry, as the speaker. Dr. Reed will present a very interesting story on the work of his bureau. Dr. R. W. Trullinger, chief, Office of Experiment Stations, will preside as chairman of the meeting.

As in the past, the meeting will be held at 11:50 a. m. in Room 6962, South Building, USDA, and friends as well as members of the A.S.A.E. will be welcome.

## Research Round Table

THE Committee on Research of the American Society of Agricultural Engineers held two round-table sessions during the Society's annual meeting at St. Louis, Missouri in June. About 40 persons were in attendance at the first session, which was opened with talks by A. W. Turner, E. A. Silver, and H. E. Pinches, followed by lively discussion for two hours mainly on categories of research. In discussing industrial research on products new to a manufacturer, Mr. Silver made the point that this should be based on the real needs of the user instead of being intended merely to match competition. Mr. Pinches pointed out the difference between applied industrial research and basic research, the latter being carried on to some extent in the large industries. The round of discussion circled the subjects; fundamental (free will) research, regional projects, major projects (with industrial support), and applied research which was summarized by F. A. Brooks.

As only a small portion of the time of the first session was devoted to the original topic "Improving Research Technique," at the second session the discussions were devoted largely to new instruments available for research work. H. J. Barre described new strain gages which can be cemented on to any surface and the strain electronically recorded. These can be attached readily to moving parts such as the pitman rod of a mower and strain recordings made while the machine is in actual use. W. V. Hukill described his thermocouple-type, hot wire anemometer which can measure convection air currents down to 6 feet per minute, or with special equipment down to 2 feet per minute. F. A. Brooks described the triple thermocouple hygrometer and called attention to the extensive use of photography as a quantitative instrument.

Following this the discussion of the group ranged around the unsolved problem of measuring accurately the moisture content of hay. There was some discussion of planning research for statistical interpretation and a plea made for analyzing observation data to the point of generalization so that the new knowledge can be applied outside the circumstantial conditions of the actual test.

## A.S.A.E. Meetings Calendar

October 31 and November 1—Pacific Northwest Section, Multnomah Hotel, Portland, Ore.

December 16 to 18—FALL MEETING, Stevens Hotel, Chicago.

December 19 and 20—3rd Barn Hay-Curing Conference, Stevens Hotel, Chicago.

## President Nichols Receives Award

A CERTIFICATE of appreciation from the U. S. War Department has been awarded to Dr. Mark L. Nichols, president of the American Society of Agricultural Engineers, and assistant chief (in charge of research), Soil Conservation Service, U. S. Department of Agriculture.

The text of the certificate reads "The War Department expresses its appreciation for patriotic service in a position of trust and responsibility to M. L. Nichols for outstanding assistance to the Ordnance Department through the advancement of the program of studying the physical characteristics of soil and applying the data obtained to the design of vehicles." The certificate bears the signatures of the Secretary of War, the Chief of Ordnance, and the Commanding General of the Army Service Forces.

## Pacific Northwest Section Meets Oct. 31

HAVING received authorization from the Council of the American Society of Agricultural Engineers, the new Pacific Northwest Section of the Society will hold its organization meeting at the Multnomah Hotel, Portland, Ore., on Thursday and Friday, October 31 and November 1, 1946. An exceedingly interesting program is promised for the occasion, details of which will be announced later.

## S.P.E.E. Is Now A.S.E.E.

BY a unanimous vote of its members present at the annual meeting at St. Louis in June, the name of the Society for the Promotion of Engineering Education has been changed to "The American Society for Engineering Education."

## Agricultural Engineering at the Allahabad Agricultural Institute

THE Allahabad Agricultural Institute, Allahabad, India, was founded as part of the work in India under the Board of Foreign Missions of the Presbyterian Church in the U.S.A. by Dr. Sam Higginbottom in 1911-12. It is one of the few well-known mission institutions which has made a large contribution to the progress of agriculture and perhaps the only one which has been able to operate on a full program during the late war period. The Institute operates under a board of directors in India and is in the process of reorganization as a union institution in which several American and probably English groups will cooperate.

The Institute teaches a four-year course in agriculture leading to a bachelor of science degree with specilization in agronomy, animal husbandry and dairying, and in horticulture. It also teaches a course in agricultural engineering leading to a bachelor of science degree. It is autonomous in organization but functions as the agricultural college of the Allahabad University, one of the leading universities in India. In addition to the two degree courses, it has junior courses in dairying and in home *(Continued on page 432)*

# Farmers Need Silos

## — here are construction methods using Douglas Fir Plywood

THE increased knowledge of the superior feeding value of grass silage and the current shortage of grain for livestock feeding have combined to cause more farmers to erect silos.

Grass silage imposes some special structural problems. The greater lateral pressures as compared to corn silage due to the higher moisture content of grass, and its greater acidity require higher unit design loads and greater attention to construction materials.

Douglas fir plywood has all of the advantages of wood construction in resisting the deterioration caused by silage acids. It has attractive structural properties, for either prefabrication or site-erection. Glued assembly is desirable for developing adequate structural strength and rigidity with minimum material. Glued plywood silos are impervious to air infiltration, do not permit leakage of silage juices and offer resistance to the freezing of silage.

Lower filling costs and greater ease in feeding out are permitted by the erection of two or more small, inexpensive silos as compared to a single large structure of the same storage capacity.

Two 8' x 24' experimental plywood silos were erected in 1942 at the University of Tennessee, one circular and the other octagonal in shape. Both were glued construction using ¼" EXTERIOR type plywood fastened with shingle nails spaced approximately 2" o.c. to hold the panels in position until the glue set. Continuous door openings with ½" steel bolt ties and vertical sliding doors of ¾" plywood were installed. Some difficulty in bending the large plywood panels to the 4' radius while working on scaffolding was the only construction problem. (See complete description, AGRICULTURAL ENGINEERING, p. 58, February, 1944).

As plywood sheets are trimmed square at the factory, butting of the joints plumbs the structure without any extra fitting or labor.

Clinching type nails used on all joints hold the plywood pieces in position while the glue cures, eliminates the use of clamps, permits uninterrupted construction, and saves time and labor. Carding nails are preferred but cut tacks, hand, shoe nails, clinch nails, or clout nails are satisfactory if they penetrate through the plywood joint from 1/4 to 3/8-inch. Backing the joint with a sledge or iron clinches the nails while driving them with a hammer. A two inch horizontal spacing and a three inch vertical spacing was satisfactory. A notched plywood straight-edge and pencil located nailing spots with dispatch.

Plywood bands, bent in the direction of the outside grain, are readily bent to a 3½ ft. radius if soaked in water from 15 to 30 minutes and stored in a circular form for later use.

Special consideration must be given to the selection of assembly adhesives for plywood silos. Casein, urea formaldehyde resin and resorcinal formaldehyde resin adhesives have been used on silos erected during the past four years with no record of failure. The resorcinal type is currently recommended because of its waterproofness and resistance to acids.

Until a better treatment is discovered it is recommended that the interior walls of plywood silos be painted with two coats of linseed oil. The outside should be painted with good quality exterior paint.

### PRELIMINARY PRESSURE TESTS

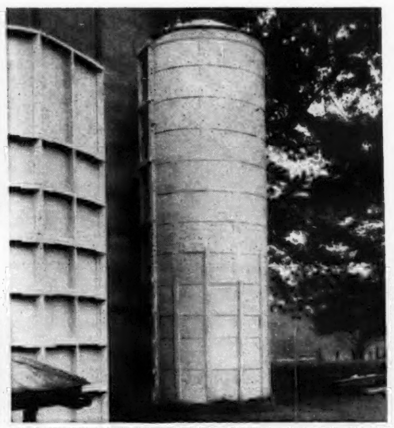
Preliminary flat panel hydrostatic pressure and deflection tests were made at the University of Tennessee, using ¼" 3-ply SolS plywood nailed and glued to framing. Glue joints were 1¾" wide, and nails were spaced 2" o.c. Two-side panels were bolted together in 4' x 4' and two 2' x 2' sizes and submitted to internal hydrostatic pressure with the following results:

| Water Pressure lbs. per sq. in | SIZE OF PANEL 4' x 4' Deflection in inches | 2' x 2' Deflection in inches | 2' x 2' Deflection in inches |
|---|---|---|---|
| 1 | 0.688 | 0.145 | |
| 2 | 1.415 | 0.445 | |
| 3 | 1.655 | 0.485 | |
| 4 | 1.780 | 0.519 | 0.416 |
| 6 | Failure (1) | 0.709 | 0.601 |
| 8 | | 1.335 | 0.782 |
| 10 | | Failure (2) | Failure (2) |

(1) Leaks occurred at defects and knots in the outer ply.

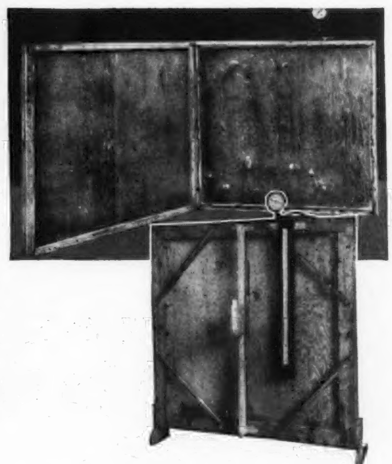
(2) The center ply or core broke or failed next to the frame. In no case did the glue joint fail.

Plywood forms for the silo pit and foundation give smooth, true concrete surfaces with a minimum of joint markings.



The completed circular silo and an octagonal design with 4' wide sides (left foreground). The flat-sided design lends itself readily to mill prefabrication with all vertical and horizontal framing nail-glued to the plywood to form panels 4' x 8'. These may be readily trucked to the farm, erected into position, and connected with ¾" plywood gussets nail-glued across the ends of the horizontal framing. The circular design might be entirely mill fabricated, trucked to the site and tipped up into position; with plywood roof and door assembly its total weight was estimated as approximately 1,000 pounds.

(Left)
An 8' diameter by 24' high circular silo erected in place with nail and glue assembly of ¼" - 4' x 8' SolS EXTERIOR type panels placed vertically. Horizontal panel joints were staggered 4' o.c. Eight inch wide bands of ¼" plywood (one thickness) were used as lateral reinforcing, to facilitate securing the cricular shape, and as gusset plates over butt-jointed wall panels. Six inch wide gusset plates of the same material were placed over the outside of vertical panel joints. Studs, 2" x 4" in size and spaced approximately 2' o.c., were bolted to anchor straps imbedded in the concrete to anchor the silo when empty; these might safely be shortened to 4' height.



ABOVE. Interior faces of 4' x 4' test panels ready to bolt together.

BELOW. Sustained hydrostatic load of 3 pounds per square inch on 4' x 4' test panels.

DOUGLAS FIR PLYWOOD ASSOCIATION
Tacoma 2, Washington

DOUGLAS FIR PLYWOOD LARGE · LIGHT · STRONG Real Wood PANELS

# NEWS SECTION

*(Continued from page 430)*

economics. Negotiations are in progress to raise the latter to degree status.

This is the only institution in India teaching a degree course in agricultural engineering and the agricultural engineering department is the largest single department of the Institute. It has a teaching schedule of about 110 hours credit, all required courses. In addition it is responsible for the administration of a supply service for the Institute which includes operation of the water system, distribution of electric current, maintenance of buildings and construction of new buildings when required. In connection with the maintenance workshop, it carries on a small implement factory, making implements designed at the Institute for the needs of the Indian farmer. Proposals are under consideration to separate the implement factory and to develop it into a separate unit. The department has a small farm on which a regular program of crop production is carried on with resident staff, giving opportunity for the testing of implements under design and practices particularly involving implements. Proposals are under consideration to set up a second farm so as to have one operated with animal power and the other to experiment with the problem of mechanizing Indian agriculture.

The Institute works in close cooperation with the provincial department of agriculture and this cooperation is particularly close in the matter of implements. At present the department does not have a separate research station primarily devoted to implement problems and so has depended to a considerable extent on the Institute for research on these lines. It is also carrying on research financed by the Central Government Council of Agricultural Research. In addition to such attention as members of the teaching staff can give to research problems, three qualified research assistants are at present employed full time on research problems.

The teaching staff sanctioned at present consists of 7 men, of whom 3 are expected to be Americans. The members of the teaching staff have opportunity to participate in research and administrative activities from time to time, though their time is primarily devoted to teaching. We are at present short one American member*.

The current food situation, along with changing political conditions, has resulted in a great awakening of interest in improving Indian agriculture and particularly in its engineering aspects. There is a widespread feeling that the implements in use must be modernized and improved; many are thinking in terms of mechanizing Indian agriculture on Western lines and some look to Russian methods. The opportunity to make a large contribution to the rapid change of the agricultural practices of a large nation are in India perhaps unique in the history of the world. The need is acute. We are training at present 12 agricultural engineers for the whole of India each year.

*For further information on the opening indicated, see the Personnel Service Bulletin in this issue.

## Personals of A.S.A.E. Members

*Alfons Alven,* for the past fourteen years district manager of the Chicago office of the Bearings Company of America, and a director of the company during the past ten years, was recently elected president of the company succeeding Henry W. Jackson. He has been engaged in the manufacture and sale of ball bearings since 1922.

*J. M. Armstrong* and *W. Kalbfleisch,* both agricultural engineers in the Experimental Farms Service, Department of Agriculture of Canada, are two of the authors of Farmer's Bulletin 111, entitled "Land Clearing," recently issued. It is a revision of a previous bulletin.

*E. L. Barringer,* formerly associated with the farm machinery division of the Chek-Chart Corporation, was recently appointed editor of "Fleet Owner" published in New York City.

*Thomas G. Blakeney,* who has been associate civil engineer in the Army Air Force, is now chief, shops and services unit, 4th Army Engineers, and is located at Fort Sam Houston, Texas.

*Albert L. Burkett* was recently transferred from his position as agricultural engineer at the Estacion Experimental Agricola de Tingo at Tingo Maria, Peru, to Havana, Cuba, where he will be engaged in research concerned with the mechanical planting, cultivating, harvesting, and processing of fiber plants other than cotton. He is employed as agricultural engineer in the technical collaboration branch, Office of Foreign Agricultural Relations, U.S. Department of Agriculture.

*Arthur W. Cooper,* who served in the U. S. Naval Reserves during the war and more recently as a member of the agricultural engineering staff at Alabama Polytechnic Institute, has accepted a position of assistant in agricultural engineering, Purdue University Agricultural Experiment Station where he will be engaged in research in farm electrification, also in taking work toward a PhD degree in engineering.

*John B. Dobie,* formerly of the agricultural engineering staff, Washington Agricultural Experiment Station, and *June Roberts* investigator, farm electricity at that station, are two of the joint authors of Bulletin No. 471, entitled "Poultry Lighting for Egg Production," issued earlier this year by that station.

*Elmer W. Gain,* who has been employed as associate drainage engineer of the U. S. Soil Conservation Service at Wapakoneta, Ohio, has been promoted to the grade of drainage engineer and transferred by the SCS to its office at Upper Darby, Pa.

*E. W. Hamilton,* of the tractor division, Allis-Chalmers Mfg. Co., addressed the 50th annual convention of the National Hay Association on July 29 at Chicago, on the subject "The Influence of Artificial Drying of Commercial Hay."

*E. A. Hardy* is author of a chapter entitled "Farm Mechanization and Electrification" in a booklet on "Canada's Agricultural Resources" published by the Dominion Department of Agriculture.

*S. Milton Henderson* has resigned as assistant research professor of agricultural engineering at Iowa State College, to accept appointment as associate professor of agricultural engineering at the University of Georgia where he will be in charge of farm machinery work.

*John W. Holliday,* who was recently placed on inactive service from the Army, has returned to the Soil Conservation Service. He is soil conservationist for the Merriweather County work unit at Greenville, Ga. He served eighteen months in the European theater where he attained the rank of captain.

*F. A. Kummer,* agricultural engineer, Alabama Agricultural Experiment Station, was the recipient recently of the Certificate of Appreciation awarded to him by the U. S. War Department for "patriotic service in a position of trust and responsibility." The certificate stated that the recognition was made for "outstanding assistance to the Ordnance Department through the application of his knowledge and experience as a soil physicist to the mechanical problems involved in increasing vehicle mobility." The award is based on Mr. Kummer's assistance to the Army Ordnance Department in the development of tank track design that made possible the greater ability of vehicles to cross muddy terrain.

*Donald E. Kusha* resigned some time ago as engineer for the Curtiss-Wright Corp., with whom he was employed during the war, and is connected with the Aero Corporation at Hollydale, Calif., as engineer on tractor-mounted implements.

*Earl M. Lewis,* who was recently discharged from the Army, is now employed as a farm service representative by the Southwestern Public Service Company at Plainview, Texas.

*Ray M. Lien* has resigned as instructor in agricultural engineering at the South Dakota State College to accept appointment as engineer with the Bureau of Reclamation, U. S. Department of Interior. He will be engaged in land development work at Ralston, Wyoming.

*James B. Loonan,* is now employed by Renfrew and Kuffler, a firm of engineers at Detroit, Michigan.

*Miss Ruby M. Loper* recently resigned as extension agricultural engineer at the University of Nebraska, to join the agricultural extension staff at Cornell University, Ithaca, N. Y. In her new work Miss Loper will carry the title "rural architect" and will be attached to the department of household arts in the College of Home Economics.

*R. W. Louden,* farm line manager, Louden Machinery Company, was elected president of the Barn Equipment Association at the recent annual meeting of that organization.

*Oscar H. Lowery,* who served as a lieutenant in the U. S. Naval Reserves during the war, has received his discharge and recently accepted a position as assistant extension agricultural engineer at Purdue University.

*Joseph C. Newell,* who was reported in a recent issue as having accepted appointment as assistant county agricultural agent for Scott County, Arkansas, and as serving as a lieutenant in the Infantry during the war, we now learn had the rank of major on his discharge in May.

*William M. Roberts,* who has been engaged on the sweet potato machinery project of the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering at Ellisville, Mississippi, recently transferred to the applications and loans division of the Rural Electrification Administration. He will be located at Washington, D. C., and will be working on the power utilization program of REA.

*Howard D. Skelton,* who has been serving as irrigation engineer for the U. S. Soil Conservation Service *(Continued on page 434)*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## Personals of A.S.A.E. Members

*(Continued from page 432)*

at Coeur d'Alene, Idaho, has been transferred to the Sunnyside Valley Irrigation District of the Yakima Project, near Grandview, Wash., where he is employed as maintenance engineer.

*B. T. Stephanson,* who has been serving as extension agricultural engineer in the department of agriculture of the Province of Alberta, Canada, is now sessional lecturer in the department of agricultural engineering at the University of Alberta, Edmonton.

*L. D. Worley* was recently promoted from the position of area engineer to district conservationist of the U. S. Soil Conservation Service at Port Gibson, Miss., and will be administratively and technically responsible for soil conservation work in five soil conservation districts in that vicinity.

*Charles C. Worstell* recently accepted employment with Mason Engineers, Inc., Milwaukee, Wis.

## Applicants for Membership

**The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.**

*J. G. Andros,* captain, U. S. Army. (Mail) CIC Center, Holabird Depot, Baltimore 19, Md.

*Lawrence J. Booher,* assistant professor of agricultural engineering, University of Arizona, Tucson, Ariz.

*Donald E. Brown,* engineering assistant, tractor engineering dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis. (Mail) 4532 W. Wells St.

*Geo. E. Bryce,* agricultural engineering specialist, Extension Service, Manitoba Department of Agriculture, Legislative Building, Winnipeg, Man., Canada.

*J. L. Butt,* graduate assistant in agricultural engineering, Alabama Polytechnic Institute, Auburn, Ala.

*Louis H. Clay,* president, Southern Tractor & Equipment Corp., 900 Jefferson Highway, New Orleans, La.

*Harry G. Cochrum,* assistant professor of rural engineering, Montana State College, Bozeman, Mont.

*Edgar W. Cowling,* assistant extension agricultural engineer, Louisiana State University, Baton Rouge, La.

*Thomas Cranage,* district sales manager, Clarage Fan Co., (Mail) 333 N. Michigan Ave., Chicago 1, Ill.

*Franklin R. Crow,* agricultural engineer, Soil Conservation Service, USDA. (Mail) Johnson City, Texas.

*C. L. Day,* instructor in agricultural engineering, University of Missouri, Columbia, Mo.

*Garland O. Edelen,* rural service representative, Louisiana Power & Light Co. (Mail) West Monroe, La.

*Carlton M. Edwards,* extension agricultural engineer, Cornell University, Ithaca, N. Y.

*R. E. Emerson,* assistant professor of agricultural engineering, West Virginia University, Morgantown, W. Va.

*Wendell M. Fairbanks,* instructor in rural engineering, Long Island Agricultural & Technical Institute, Farmingdale, N. Y. (Mail) 671 Main St.

*James O. Frazier,* captain, U. S. Army. (Mail) Mil. Tng. Division, Post Headquarters, Belvoir, Va.

*Owen L. Garretson,* manager, mechanical equipment div., Chemical engineering dept., Phillips Petroleum Co., Bartlesville, Okla.

*Howard W. Graybill,* engineer, New Holland Machine Co., New Holland, Pa.

*R. R. Harris,* assistant professor of agricultural engineering, University of Georgia, Athens, Ga.

*Joseph N. Howard,* agricultural engineer, Duke Power Co. (Mail) Greensboro, N. C.

*Walter D. Hunnicutt,* manager of procurement and supply, National Dairy Products Co., Inc., 75 E. Wacker Drive, Chicago 1, Ill.

*Wayne M. Hypes,* assistant work unit conservationist, Soil Conservation Service, USDA. (Mail) Box 306, Albemarle, N. C.

*Paul E. Johnson,* instructor in agricultural engineering, Purdue University, Lafayette, Ind.

*W. Floyd Keepers,* executive secretary, Barn Equipment Association, 4300 Board of Trade Building, 141 W. Jackson Blvd., Chicago 4, Ill.

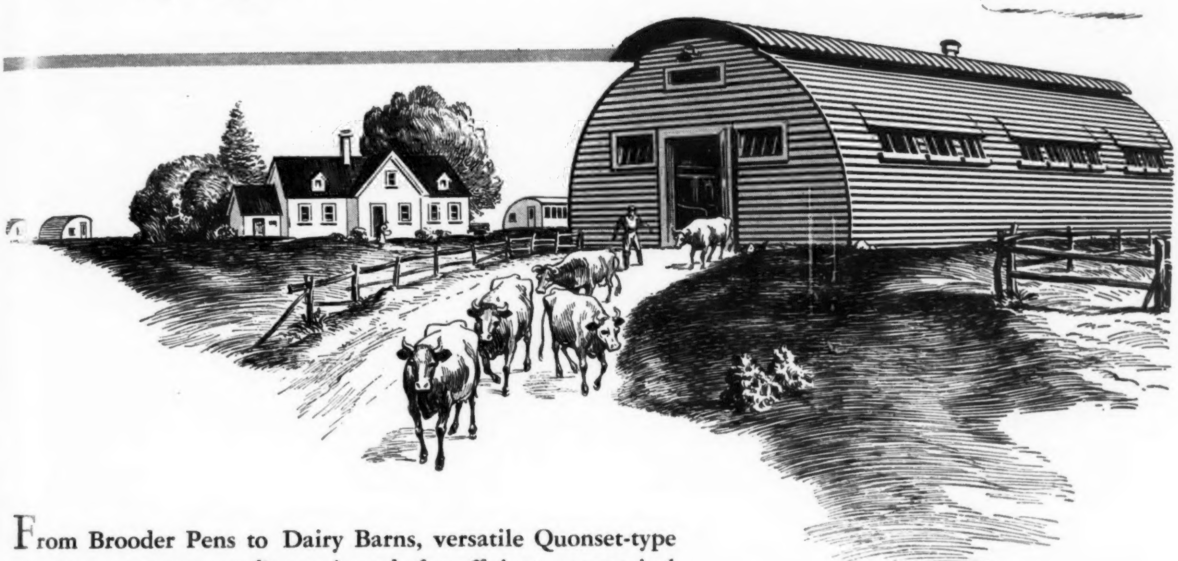
*Samuel B. Land,* assistant county agent, Boydton, Va.

*E. H. Leslie,* technical director, Blaw-Knox Company. (Mail) 1831 Traver Rd., Ann Arbor, Mich.

*James C. Ma,* designing engineer, S. L. Allen & Co., Inc., 5th St. & Glenwood Ave., Philadelphia 40, Pa.

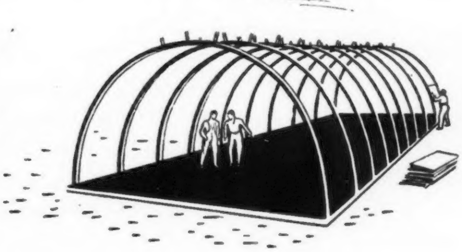
*(Continued on page 436)*

# *Getting the <u>Most</u> out of QUONSETS...*



From Brooder Pens to Dairy Barns, versatile Quonset-type structures meet many farmers' needs for efficient, economical outbuildings.

But . . . like everything else . . . sound planning makes them better.



For instance, proper insulation is important. For this job, Flintkote Insulating Wool, made of Fiberglas*, is just the thing. It's *clean* . . . won't rot or mildew, support vermin, or absorb odors. It's *safe* . . . highly fire-retardant. And it's efficient . . . its thermal conductivity is established in the ASHVE Guide as "K"=.27 BTU. This is the figure recommended in computing heat losses from buildings.

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Recommend Flintkote Static† Asphalt for the exterior. This stable asphalt emulsion dampproofs and protects metal sheathing from corrosion for many a long year.

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## Applicants for Membership

*(Continued from page 434)*

*A. J. McManus*, Electricity Supply Board. (Mail) Bridge-End, Lifford, Co. Donegal, Ireland.

*T. A. Mercer, Jr.*, rural service engineer, Ohio Edison Co. (Mail) Salem, Ohio.

*D. O. H. Miller*, designing engineer, John Deere Harvester Works of Deere & Co. (Mail) 2215 10th St., East Moline, Ill.

*Kenneth C. Mock*, assistant agricultural engineer, Everglades Experiment Station. (Mail) P. O. Box 203, Pahokee, Fla.

*Albert S. Mowery*, instructor in agricultural engineering, Pennsylvania State College, State College, Pa.

*Lacy M. Peoples*, utilization specialist, U. S. Bonneville Power Administration, P .O. Box 3537, Portland, Ore.

*Robert H. Rea*, manager, Texas Farm Management, Box 26, Weatherford, Texas.

*B. P. Rines*, Walnut Crest Farm, Westbrook, Maine.

*E. M. Rolwing*, overseer, Rolwing Farms, Box 48, Cairo, Ill.

*John R. Sartin*, rural service representative, Louisiana Power & Light Co. (Mail) 711 Second St., Gretna, La.

*John N. Selby*, soil conservationist, Soil Conservation Service, USDA. (Mail) Boydton, Va.

*M. S. Skelton*, junior agricultural engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA. (Mail) Box 792, Tillage Machinery Lab., Auburn, Ala.

*Robert E. Skinner*, graduate student, Iowa State College, Ames, Iowa. (Mail) 158 Hyland Ave.

*James B. Smith*, R. R. No. 1, South Hill, Va.

*James M. Stanley*, assistant extension agricultural engineer, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) General Delivery.

*William H. Tamm*, engineer and assistant chief, design section, U. S. Engineers Office, Fort Norfolk, Va. (Mail) 7423 W. Kenmore Drive, Norfolk 5.

*C. W. Terry*, department of agricultural engineering, Cornell University, Ithaca, N. Y.

*Glifford H. Towle*, missionary and pastor, American Board of Commissioners for Foreign Missions. (Mail) Forest Home, Ithaca, N. Y.

*Claude W. Walz*, chief engineer, experimental department, John Deere Wagon Works of Deere & Co., Moline, Ill.

*Leroy Willis, auditor*, P. O. Box 593, Lynn Haven, Fla.

*Galen C. Winter*, Farm Equipment Institute, 608 S. Dearborn St., Chicago 5, Ill.

*William A. Womack*, owner, Rockey Creek Farms, Ashford, Ala.

TRANSFER OF GRADES

John M. Anderson, farm structures engineer, Structural Clay Products Institute, 120½ Welch Ave., Ames, Iowa. (Junior Member to Member)

*Robert E. Hartsock*, chief engineer, Aerco Corp. (Mail) 5631 Uir Campo, Los Angeles 22, Calif. (Junior Member to Member)

*Reuben B. Hicks*, agricultural engineer, Southside Electric Coop., Crewe, Va. (Junior Member to Member)

*M. F. Mueller*, territory supervisor, J. I. Case Company. (Mail) 323 Eddy Ave., Missoula, Mont. (Junior Member to Member)

*H. J. Stockwell*, associate irrigation engineer, Soil Conservation Service, USDA, Fort Collins, Colo. (Mail) 638 S. Grant. (Junior Member to Member)

*Norman C. Teter*, research agricultural engineer, North Carolina State College, Raleigh, N. C. (Junior Member to Member)

## New Literature

*"Automotive Serviceman's Handy Handbook."* Paper, 48 pages, 3.75x7 inches, indexed. Burd Piston Ring Co. 50 cents. Relates sound practices to principles in servicing the inernal-combustion engine. Covers specifically the carburetor, ignition parts and timing, cooling system, bearings and oiling system, valves, cylinder head and walls, and pistons and piston rings.

GREEN FIELDS ARE GOLD. Joint Committee on Grassland Farming (Executive Secretary, Box 30, Norwich, N. Y.) Paper. 42 pages, 5½x7½ inches. No price stated. Introductory remarks, 102 questions and answers, and testimonials, designed to give a practical digest of information on grassland farming. The Joint Committee includes representatives of the American Society of Agricultural Engineers, American Society of Animal Production, American Society of Agronomy, American Dairy Science Association, National Fertilizer Association, National Association of Silo Manufacturers, Farm Equipment Institute, and the Soil Science Society of America.

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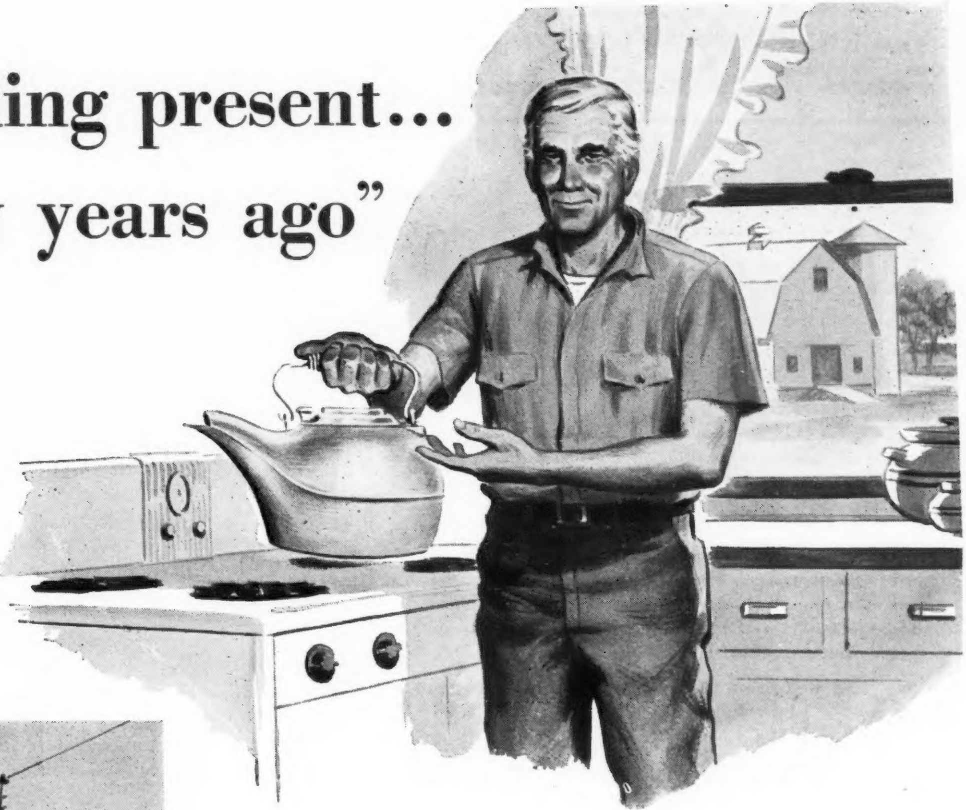

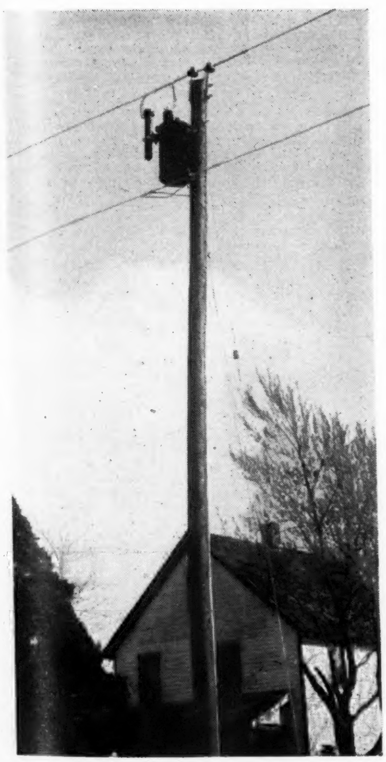

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## PERSONNEL SERVICE BULLETIN

*(Continued from page 438)*

AGRICULTURAL ENGINEER desires research or development in soil and water or farm structures field, with private company. BSAE deg, University of Georgia. Experience in engineering department of Bell Aircraft Corp., in structural development and lofting work for 3½ years. No physical defects. Available now. Married. Age 26. Salary $3600. W-336

FARM MANAGER with additional engineering training and experience, desires extension or research work in soil conservation or other branches of agricultural engineering. BSA deg, North Dakota State College, 1915, with major in farm management and minor in agricultural engineering. Additional study in production management, time study, mathematics, and drafting. Varied experience in farm management, county agent work, machining, drafting, and painting. No physical defects. Available within one month after acceptance. Married. Age 58. Salary $2700-3000. W-337

AGRICULTURAL ENGINEER desires production or development engineering with industry; survey or project development with government agency; or college extension or research work. BSAE deg, Pennsylvania State College, 1942. Experience as farm manager for absentee owner, and diesel engineer on naval mine, patrol and escort vessels. No physical defects. Available now. Single. Age 27. Salary open. W-339

AGRICULTURAL ENGINEER desires design and development, sales engineering, service, or educational work in farm machinery or electrification field. BSAE deg, Iowa State College, 1941. US Navy diesel engineering training, 4 months. Promotion to Lt. (Senior grade). No physical defects. Available up to Sept. 23 or after Feb. 1, 1947 (planning additional study in electrical engineering if not employed before Sept. 23). Married. Age 27. Salary open. W-341

AGRICULTURAL ENGINEER desires research, development, service or teaching in soil and water, farm machinery, or farm structures field. BSAE deg, University of Minnesota, 1940. Experience as aeronautical map draftsman; chief of field party on airport survey; instructor in drawing and blueprint reading. Two years in Army Air Force. No physical defects. Available now. Single. Age 33. Salary $2000 min. W-342

AGRICULTURAL ENGINEER desires research, extension, or project engineering work in rural electric or farm structures field. BSAE deg, University of Georgia, 1943. Army experience, 3½ years, partly in transportation. Promoted to 1st Lt. No physical defects. Available Sept. 1-15. Single. Age 22. Salary $2400. W-343

AGRICULTURAL ENGINEER desires college teaching and research work. BSAE deg, Washington State College, 1933; MSA deg and AE deg, 1939; Ph D in electrical-agricultural engineering, Iowa State College, 1946. Extensive experience in research, teaching, extension, and engineering administration in agricultural and electrical engineering fields. No physical defects. Available on or before Oct. 1. Married. Age 36. Salary open. W-344.

AGRICULTURAL ENGINEER desires design and development, sales or service work in the power and machinery field, or work with firm of consulting engineers. BSAE deg, South Dakota State College, 1941. Experience with highway department as rodman and concrete inspector, in Soil Conservation Service as junior engineer in drainage work, and in Army as maintenance engineer in Air Corps, with 3 years foreign service and promotion to Major. No physical defects. Available Dec. 1. Married. Age 29. Salary $3000. W-345

AGRICULTURAL ENGINEER desires development work in farm machinery or farm structures field. BSAE deg, Pennsylvania State College. Experience on home dairy farm, and as officer in Corps of Engineers. Served as Area Engineer 3 years with responsibility for construction of Army installations, and assistance in turnover of engineering war surpluses and preparation of Reciprocal Aid reports. Promoted to Captain, C E. No physical defects. Available Oct. 15. Single. Age 24. Salary $3000. W-346

AGRICULTURAL ENGINEER desires sales engineering or extension work in the farm power and machinery field. BSAE deg, Iowa State College, 1940. Experience in extension work, drafting on combines and threshers for farm equipment manufacturer, drafting for aircraft manufacturer, farming, and in Navy as electronic technician. No physical defects. Available October 1. Single. Age 29. Salary $3300 min. W-347